LM393B, LM2903B, LM193, LM293, LM393 and LM2903 Dual Comparators

1 Features

- NEW LM393B and LM2903B
- Improved specifications of B-version
  - Maximum rating: up to 38 V
  - ESD rating (HBM): 2k V
  - Low input offset: 0.37 mV
  - Low input bias current: 3.5 nA
  - Low supply-current: 200 µA per comparator
  - Faster response time of 1 µsec
  - Extended temperature range for LM393B
  - Available in tiny 2 x 2mm WSON package
- B-version is drop-in replacement for LM293, LM393 and LM2903, A and V versions
- Common-mode input voltage range includes ground
- Differential input voltage range equal to maximum-rated supply voltage: ±38 V
- Low output saturation voltage
- Output compatible with TTL, MOS, and CMOS

2 Applications

- Vacuum robot
- Single phase UPS
- Server PSU
- Cordless power tool
- Wireless Infrastructure
- Applicances
- Building Automation
- Factory automation & control
- Motor drives
- Infotainment & cluster

3 Description

The LM393B and LM2903B devices are the next generation versions of the industry-standard LM393 and LM2903 comparator family. These next generation B-version comparators provide outstanding value for cost-sensitive applications featuring lower offset voltage, higher supply voltage capability, lower supply current, lower input bias current, lower propagation delay, and improved 2 kV ESD performance and input ruggedness through dedicated ESD clamps. The LM393B and LM2903B can drop-in replace the LM293, LM393 and LM2903, for both "A" and "V" grades.

All devices consist of two independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages. Quiescent current is independent of the supply voltage, and the outputs can be connected to other open-collector outputs to achieve wired-AND relationships.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LM393B, LM2903B, LM193, LM293, LM293A, LM393, LM393A, LM2903, LM2903V, LM2903AV	SOIC (8)	4.90 mm x 3.91 mm
LM393B, LM2903B, LM293, LM293A, LM393, LM393A, LM2903	VSSOP (8)	3.00 mm x 3.00 mm
LM293, LM393, LM393A, LM2903	PDIP (8)	9.81 mm × 6.35 mm
LM393, LM393A, LM2903	SO (8)	6.20 mm x 5.30 mm
LM393B, LM2903B, LM393, LM393A, LM2903, LM2903V, LM2903AV	TSSOP (8)	3.00 mm x 4.40 mm
LM393B	SOT-23 (8)	2.90 mm x 1.60 mm
LM393B, LM2903B	WSON (8)	2.00 mm × 2.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Family Comparison Table

Specification	LM393B	LM2903B	LM393 LM393A	LM2903	LM2903V LM2903AV	LM193	LM293 LM293A	Units
Supply Votlage	3 to 36	3 to 36	2 to 30	2 to 30	2 to 32	2 to 30	2 to 30	V
Total Supply Current (5V to 36V max)	0.6 to 0.8	0.6 to 0.8	1 to 2.5	1 to 2.5	1 to 2.5	1 to 2.5	1 to 2.5	mA
Temperature Range	−40 to 85	−40 to 125	0 to 70	−40 to 125	−40 to 125	−55 to 125	−25 to 85	°C
ESD (HBM)	2000	2000	1000	1000	1000	1000	1000	V
Offset Voltage (Max over temp)	± 4	± 4	± 9 ± 4	± 15	± 15 ± 4	± 9	± 9 ± 4	V
Input Bias Current (typ / max)	3.5 / 25	3.5 / 25	25 / 250	25 / 250	25 / 250	25 / 100	25 / 250	nA
Response Time (typ)	1	1	1.3	1.3	1.3	1.3	1.3	µsec

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision AB (December 2019) to Revision AC — **Page**

- Changed front page Features, Applications and Description text to highlight B version. ... 1
- Added WSON and SOT-23-8 packages. ... 1
- Added Links to Family Table ... 1
- Added DDF and DSG pkgs to Thermal Table ... 5

Changes from Revision AA (September 2019) to Revision AB — **Page**

- Changed LM393B and LM2903B from Preview to Active status ... 1
- Added Family Comparison Table ... 1

Changes from Revision Z (October 2017) to Revision AA — **Page**

- Added "B" devices with various text changes throughout datasheet. ... 1
- Deleted from Device Information old LM193 CDIP and LCCC package references and drawings. These are on the LM139-MIL datasheet. ... 1
- Added "B" devices Thermal Information table. ... 5
- Added "B" device electrical tables ... 6
- Added "B" device graphs ... 12

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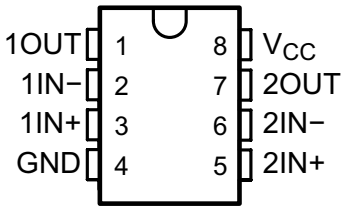
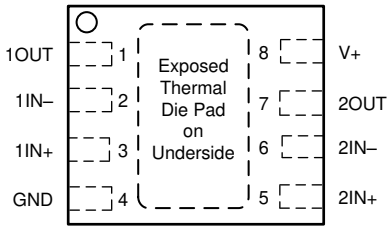
5 Pin Configuration and Functions

D, DGK, JG, P, PS, DDF or PW Package
8-Pin SOIC, VSSOP, PDIP, SO, or TSSOP
Top View



DSG Package
8-Pin WSON With Exposed Pad
Top View



Connect thermal pad directly to GND pin.

Pin Functions

PIN			I/O	DESCRIPTION
NAME	SOIC, VSSOP, PDIP, SO, DDF and TSSOP	DSG		
1OUT	1	1	Output	Output pin of comparator 1
1IN–	2	2	Input	Negative input pin of comparator 1
1IN+	3	3	Input	Positive input pin of comparator 1
GND	4	4	—	Ground
2IN+	5	5	Input	Positive input pin of comparator 2
2IN-	6	6	Input	Negative input pin of comparator 2
2OUT	7	7	Output	Output pin of comparator 2
V_{CC}	8	8	—	Positive Supply
Thermal Pad	—	PAD	—	Connect directly to GND pin

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6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

			MIN	MAX	UNIT
V_{CC}	Supply voltage (2)	Non-B Versions	–0.3	36	V
		B Versions Only		38	
V_{ID}	Differential input voltage (3)	Non-B Versions	-36	36	V
		B Versions Only	-38	38	
V_I	Input voltage (either input)	Non-B Versions	–0.3	36	V
		B Versions Only		38	
I_{IK}	Input current (4)			-50	mA
V_O	Output voltage	Non-B Versions	–0.3	36	V
		B Versions Only		38	
I_O	Output current	Non-B Versions		20	mA
		B Versions Only		25	
I_{SC}	Duration of output short circuit to ground (5)		Unlimited		
T_J	Operating virtual-junction temperature			150	°C
T_{stg}	Storage temperature		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. Production Processing Does Not Necessarily Include Testing of All Parameters.
(2) All voltage values, except differential voltages, are with respect to network ground.
(3) Differential voltages are at IN+ with respect to IN–.
(4) Input current flows thorough parasitic diode to ground and turns on parasitic transistors that increases I_{CC} and may cause output to be incorrect. Normal operation resumes when input current is removed.
(5) Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.

6.2 ESD Ratings

			VALUE	UNIT
LM393B and LM2903B Only				
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 (2)	±1000	
All Other Versions				
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±1000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 (2)	±750	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

		MIN	MAX	UNIT
Supply voltage, $V_S = (V+) – (V–)$	non-V devices	2	30	V
	V devices	2	32	
	"B" version devices	3	36	
Input voltage range, V_{IVR}	non-B devices	0	(V+) – 2.0	V
	"B" version devices	–0.1		
Ambient temperature, T_A	LM193	–55	125	°C
	LM2903, LM2903V, LM2903AV, LM2903B	–40	125	
	LM393B	–40	85	
	LM293, LM293A	–25	85	
	LM393, LM393A	0	70	

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6.4 Thermal Information: LM193

THERMAL METRIC(1)		LM193 D (SOIC) 8 pin	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	126.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	70	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	64.9	°C/W
ψ_{JT}	Junction-to-top characterization parameter	20.3	°C/W
ψ_{JB}	Junction-to-board characterization parameter	64.5	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

6.5 Thermal Information: LM293, LM393, LM2903 (all 'V' and 'A' suffixes)

THERMAL METRIC(1)		LM293, LM393, LM2903					UNIT
		D (SOIC)	DGK (VSSOP)	P (PDIP)	PS (SO)	PW (TSSOP)	
		8 pin	8 pin	8 pin	8 pin	8 pin	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	131.8	199.4	73.7	139	194.1	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	78.4	90.2	62.6	98.9	77.0	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	72.2	120.8	50.8	83.7	123.0	°C/W
ψ_{JT}	Junction-to-top characterization parameter	26.5	21.5	39.2	47.4	13.1	°C/W
ψ_{JB}	Junction-to-board characterization parameter	71.1	119.1	50.7	83	121.3	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

6.6 Thermal Information: LM393B and LM2903B

THERMAL METRIC(1)		LM393B, LM2903B					UNIT
		D (SOIC)	PW (TSSOP)	DGK (VSSOP)	DDF (SOT-23)	DSG (WSON)	
		8 pin	8 pin	8 pin	8 pin	8 pins	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	148.5	200.6	193.7	197.9	96.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	90.2	89.6	82.9	119.2	119.0	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	91.8	131.3	115.5	115.4	63.1	°C/W
ψ_{JT}	Junction-to-top characterization parameter	38.5	22.1	20.8	19.4	12.4	°C/W
ψ_{JB}	Junction-to-board characterization parameter	91.1	129.6	113.9	113.7	63.0	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	-	-	-	-	37.8	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

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6.7 Electrical Characteristics LM393B

V_S = 5 V, V_{CM} = (V–) ; T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	V_S = 5 to 36V	–2.5	±0.37	2.5	mV
		V_S = 5 to 36V, T_A = –40°C to +85°C	–4		4	
I_B	Input bias current			–3.5	–25	nA
		T_A = –40°C to +85°C			–50	nA
I_{OS}	Input offset current		–10	±0.5	10	nA
		T_A = –40°C to +85°C	–25		25	nA
V_{CM}	Common mode range	V_S = 3 to 36V	(V–)		(V+) – 1.5	V
V_{CM}	Common mode range	V_S = 3 to 36V, T_A = –40°C to +85°C	(V–)		(V+) – 2.0	V
A_{VD}	Large signal differential voltage amplification	V_S = 15V, V_O = 1.4V to 11.4V; R_L ≥ 15k to (V+)	50	200		V/mV
V_{OL}	Low level output Voltage {swing from (V–)}	I_{SINK} ≤ 4mA, V_{ID} = -1V		110	400	mV
		I_{SINK} ≤ 4mA, V_{ID} = -1V T_A = –40°C to +85°C			550	mV
I_{OH-LKG}	High-level output leakage current	(V+) = V_O = 5 V; V_{ID} = 1V		0.1	20	nA
		(V+) = V_O = 36V; V_{ID} = 1V		0.3	50	nA
I_{OL}	Low level output current	V_{OL} = 1.5V; V_{ID} = -1V; V_S = 5V	6	21		mA
I_Q	Quiescent current (all comparators)	V_S = 5 V, no load		400	600	µA
		V_S = 36 V, no load, T_A = –40°C to +85°C		550	800	µA

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6.8 Electrical Characteristics LM2903B

V_S = 5 V, V_{CM} = (V–) ; T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	V_S = 5 to 36V	–2.5	±0.37	2.5	mV
		V_S = 5 to 36V, T_A = –40°C to +125°C	–4		4	
I_B	Input bias current			–3.5	–25	nA
		T_A = –40°C to +125°C			–50	nA
I_{OS}	Input offset current		–10	±0.5	10	nA
		T_A = –40°C to +125°C	–25		25	nA
V_{CM}	Common mode range	V_S = 3 to 36V	(V–)		(V+) – 1.5	V
		V_S = 3 to 36V, T_A = –40°C to +125°C	(V–)		(V+) – 2.0	V
A_{VD}	Large signal differential voltage amplification	V_S = 15V, V_O = 1.4V to 11.4V; R_L ≥ 15k to (V+)	50	200		V/mV
V_{OL}	Low level output Voltage {swing from (V–)}	I_{SINK} ≤ 4mA, V_{ID} = -1V		110	400	mV
		I_{SINK} ≤ 4mA, V_{ID} = -1V T_A = –40°C to +125°C			550	mV
I_{OH-LKG}	High-level output leakage current	(V+) = V_O = 5 V; V_{ID} = 1V		0.1	20	nA
		(V+) = V_O = 36V; V_{ID} = 1V		0.3	50	nA
I_{OL}	Low level output current	V_{OL} = 1.5V; V_{ID} = -1V; V_S = 5V	6	21		mA
I_Q	Quiescent current (all comparators)	V_S = 5 V, no load		400	600	µA
		V_S = 36 V, no load, T_A = –40°C to +125°C		550	800	µA

6.9 Switching Characteristics LM393B and LM2903B

V_S = 5V, V_{O_PULLUP} = 5V, V_{CM} = V_S/2, C_L = 15pF, R_L = 5.1k Ohm, T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{response}$	Propagation delay time, high-to-low; TTL input signal (1)	TTL input with V_{ref} = 1.4V		300		ns
$t_{response}$	Propagation delay time, high-to-low; Small scale input signal (1)	Input overdrive = 5mV, Input step = 100mV		1000		ns

(1) High-to-low and low-to-high refers to the transition at the input.

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6.10 Electrical Characteristics for LM193, LM293, and LM393 (without A suffix)

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A [1]	LM193			LM293 LM393			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, V_{IC} = V_{ICR} min, V_O = 1.4 V		25°C		2	5		2	5	mV
				Full range			9			9	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		3	25		5	50	nA
				Full range			100			250	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–25	–100		–25	–250	nA
				Full range			–300			–400	
V_{ICR}	Common-mode input-voltage range [2]			25°C	0 to V_{CC} – 1.5			0 to V_{CC} – 1.5			V
				Full range	0 to V_{CC} – 2			0 to V_{CC} – 2			
A_{VD}	Large-signal differential-voltage amplification	V_{CC} = 15 V, V_O = 1.4 V to 11.4 V, R_L ≥ 15 kΩ to V_{CC}		25°C	50	200		50	200		V/mV
I_{OH}	High-level output current	V_{OH} = 5 V	V_{ID} = 1 V	25°C		0.1			0.1	50	nA
		V_{OH} = 30 V	V_{ID} = 1 V	Full range			1			1	µA
V_{OL}	Low-level output voltage	I_{OL} = 4 mA,	V_{ID} = –1 V	25°C		150	400		130	400	mV
				Full range			700			700	
I_{OL}	Low-level output current	V_{OL} = 1.5 V,	V_{ID} = –1 V	25°C	6			6			mA
I_{CC}	Supply current	R_L = ∞	V_{CC} = 5 V	25°C		0.8	1		0.45	1	mA
			V_{CC} = 30 V	Full range			2.5		0.55	2.5	

(1) Full range (minimum or maximum) for LM193 is –55°C to 125°C, for LM293 is –25°C to 85°C, and for LM393 is 0°C to 70°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

(2) The voltage at either input should not be allowed to go negative by more than 0.3 V otherwise output may be incorrect and excessive input current can flow. The upper end of the common-mode voltage range is limited by V_{CC} – 2V. However only one input needs to be in the valid common mode range, the other input can go up the maximum V_{CC} level and the comparator provides a proper output state. Either or both inputs can go to maximum V_{CC} level without damage.

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6.11 Electrical Characteristics for LM293A and LM393A

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A (1)	LM293A LM393A			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, V_O = 1.4 V, V_{IC} = $V_{ICR(min)}$		25°C		1	2	mV
				Full range			4	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		5	50	nA
				Full range			150	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–25	–250	nA
				Full range			–400	
V_{ICR}	Common-mode input-voltage range (2)			25°C	0 to V_{CC} – 1.5			V
				Full range	0 to V_{CC} – 2			
A_{VD}	Large-signal differential-voltage amplification	V_{CC} = 15 V, V_O = 1.4 V to 11.4 V, R_L ≥ 15 kΩ to V_{CC}		25°C	50	200		V/mV
I_{OH}	High-level output current	V_{OH} = 5 V,	V_{ID} = 1 V	25°C		0.1	50	nA
		V_{OH} = 30 V,	V_{ID} = 1 V	Full range			1	µA
V_{OL}	Low-level output voltage	I_{OL} = 4 mA,	V_{ID} = –1 V	25°C		110	400	mV
				Full range			700	
I_{OL}	Low-level output current	V_{OL} = 1.5 V,	V_{ID} = –1 V,	25°C	6			mA
I_{CC}	Supply current	R_L = ∞	V_{CC} = 5 V	25°C		0.60	1	mA
			V_{CC} = 30 V	Full range		0.72	2.5	

(1) Full range (minimum or maximum) for LM293A is –25°C to 85°C, and for LM393A is 0°C to 70°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.

(2) The voltage at either input should not be allowed to go negative by more than 0.3 V otherwise output may be incorrect and excessive input current can flow. The upper end of the common-mode voltage range is limited by V_{CC} – 2V. However only one input needs to be in the valid common mode range, the other input can go up the maximum V_{CC} level and the comparator provides a proper output state. Either or both inputs can go to maximum V_{CC} level without damage.

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6.12 Electrical Characteristics for LM2903, LM2903V, and LM2903AV

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A (1)	LM2903, LM2903V			LM2903AV			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX (2), V_O = 1.4 V, V_{IC} = $V_{ICR(min)}$,		25°C		2	7		1	2	mV
				Full range			15			4	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		5	50		5	50	nA
				Full range			200			200	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–25	–250		–25	–250	nA
				Full range			–500			–500	
V_{ICR}	Common-mode input-voltage range (3)			25°C	0 to V_{CC} – 1.5			0 to V_{CC} – 1.5			V
				Full range	0 to V_{CC} – 2			0 to V_{CC} – 2			
A_{VD}	Large-signal differential-voltage amplification	V_{CC} = 15 V, V_O = 1.4 V to 11.4 V, R_L ≥ 15 kΩ to V_{CC}		25°C	25	100		25	100		V/mV
I_{OH}	High-level output current	V_{OH} = 5 V,	V_{ID} = 1 V	25°C		0.1	50		0.1	50	nA
		V_{OH} = V_{CC} MAX (2),	V_{ID} = 1 V	Full range			1			1	µA
V_{OL}	Low-level output voltage	I_{OL} = 4 mA,	V_{ID} = –1 V,	25°C		150	400		150	400	mV
				Full range			700			700	
I_{OL}	Low-level output current	V_{OL} = 1.5 V,	V_{ID} = –1 V	25°C	6			6			mA
I_{CC}	Supply current	R_L = ∞	V_{CC} = 5 V	25°C		0.8	1		0.8	1	mA
			V_{CC} = MAX	Full range			2.5			2.5	

(1) Full range (minimum or maximum) for LM2903 is –40°C to 125°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
(2) V_{CC} MAX = 30 V for non-V devices and 32 V for V-suffix devices.
(3) The voltage at either input should not be allowed to go negative by more than 0.3 V otherwise output may be incorrect and excessive input current can flow. The upper end of the common-mode voltage range is limited by V_{CC} – 2V. However only one input needs to be in the valid common mode range, the other input can go up the maximum V_{CC} level and the comparator provides a proper output state. Either or both inputs can go to maximum V_{CC} level without damage.

6.13 Switching Characteristics: LM193, LM239, LM393, LM2903, all 'A' and 'V' versions

V_{CC} = 5 V, T_A = 25°C

PARAMETER	TEST CONDITIONS		TYP	UNIT
Response time	R_L connected to 5 V through 5.1 kΩ, C_L = 15 pF (1)(2)	100-mV input step with 5-mV overdrive	1.3	µs
		TTL-level input step	0.3	

(1) C_L includes probe and jig capacitance.
(2) The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.

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6.14 Typical Characteristics, LMx93, LM2903 (all 'V' and 'A' suffixes)

T_A= 25°C, V_S= 5V, R_{PULLUP}=5.1k, C_L = 15 pF, V_{CM}=0V unless otherwise noted.

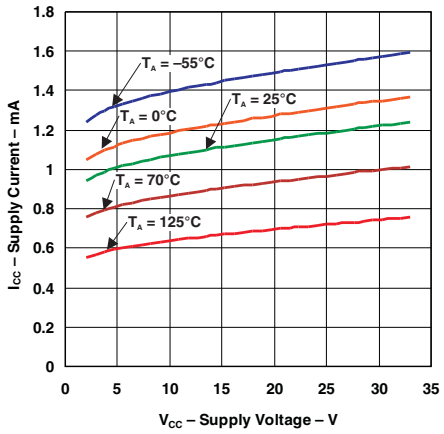

Figure 1. Supply Current vs Supply Voltage

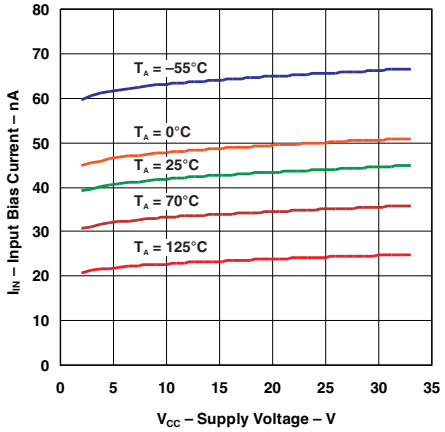

Figure 2. Input Bias Current vs Supply Voltage

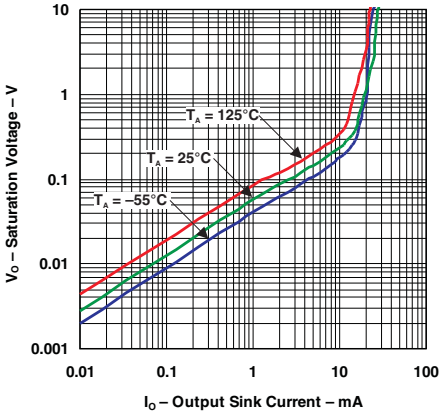

Figure 3. Output Saturation Voltage

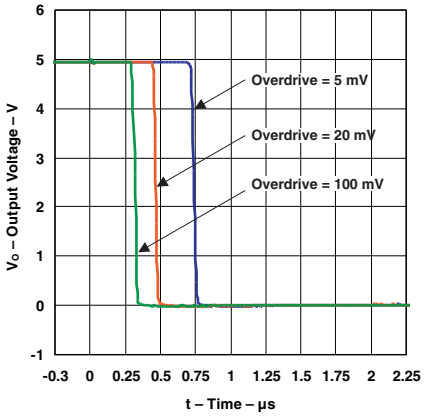

Figure 4. Response Time for Various Overdrives Negative Transition

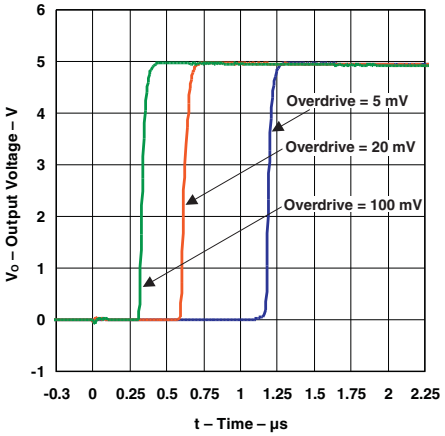

Figure 5. Response Time for Various Overdrives Positive Transition

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6.15 Typical Characteristics, LM393B and LM2903B

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

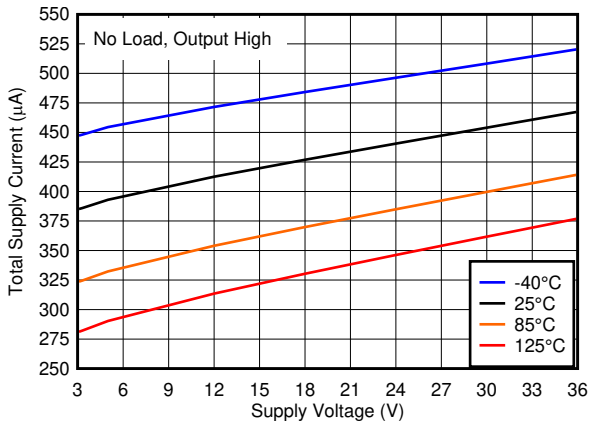

Figure 6. Total Supply Current vs. Supply Voltage

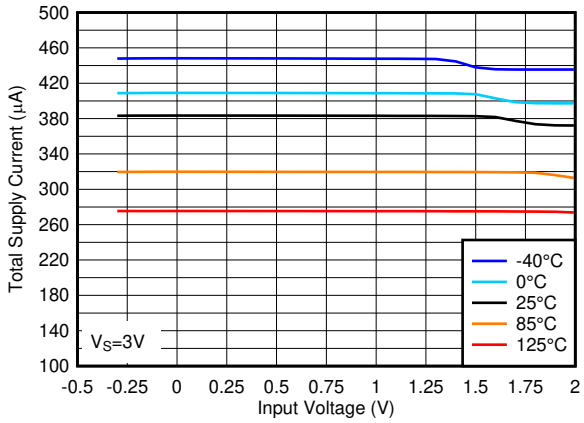

Figure 7. Total Supply Current vs. Input Voltage at 3V

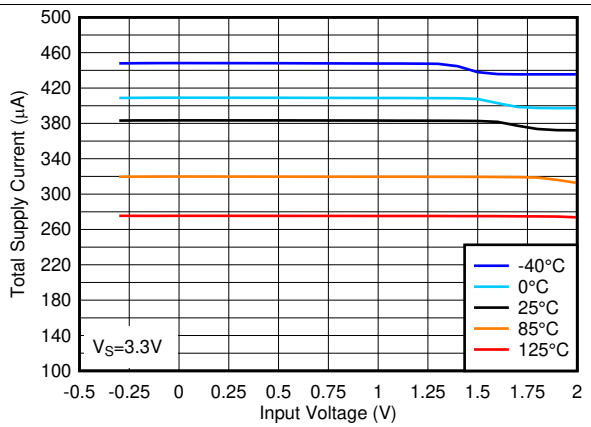

Figure 8. Total Supply Current vs. Input Voltage at 3.3V

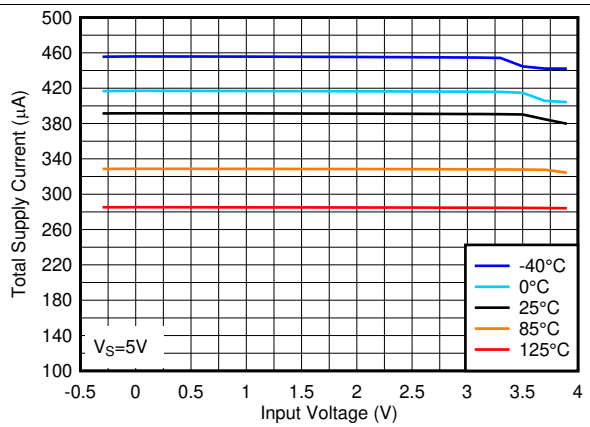

Figure 9. Total Supply Current vs. Input Voltage at 5V

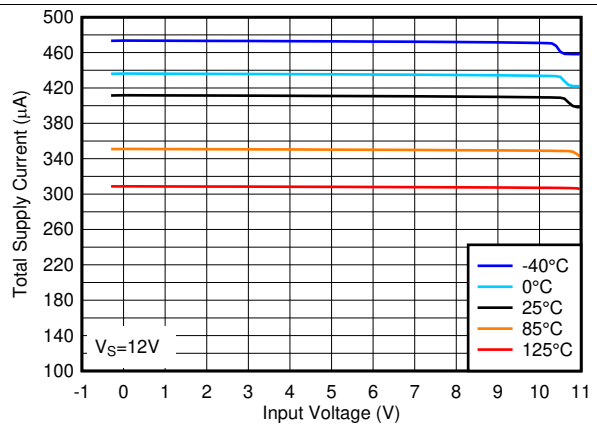

Figure 10. Total Supply Current vs. Input Voltage at 12V

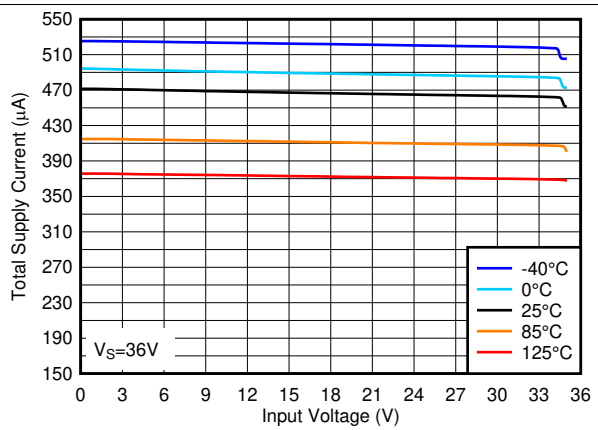

Figure 11. Total Supply Current vs. Input Voltage at 36V

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Typical Characteristics, LM393B and LM2903B (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

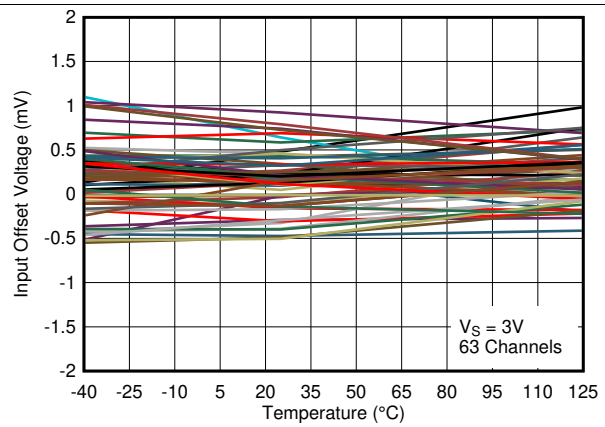

Figure 12. Input Offset Voltage vs. Temperature at 3V

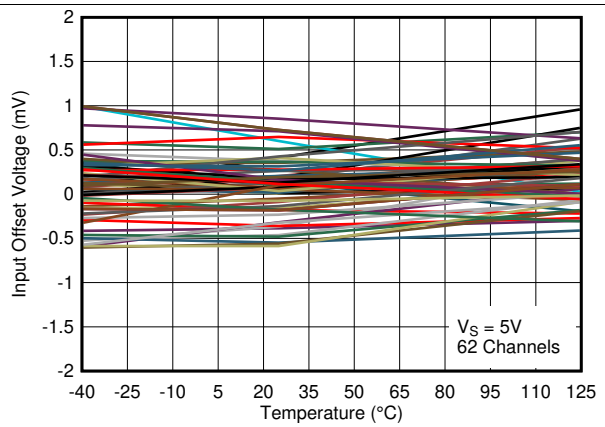

Figure 13. Input Offset Voltage vs. Temperature at 5V

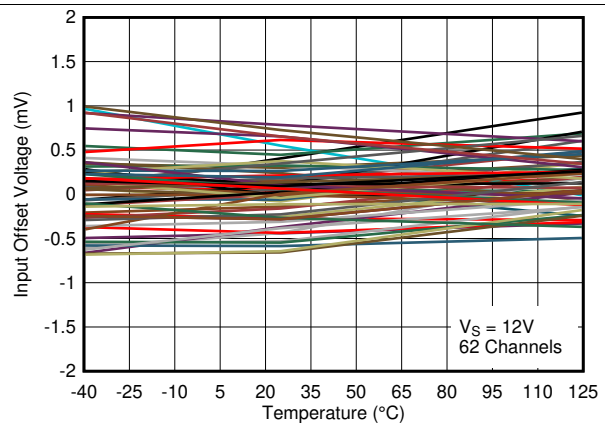

Figure 14. Input Offset Voltage vs. Temperature at 12V

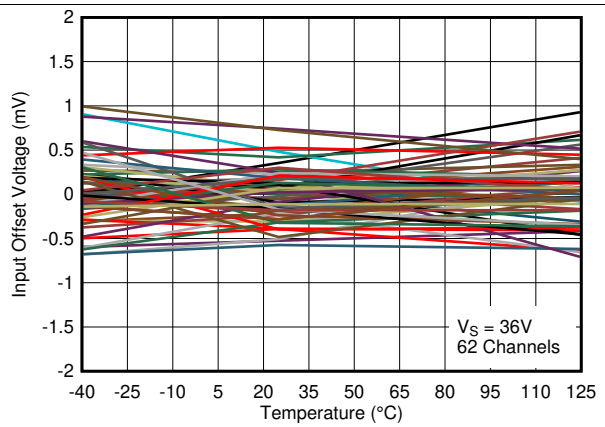

Figure 15. Input Offset Voltage vs. Temperature at 36

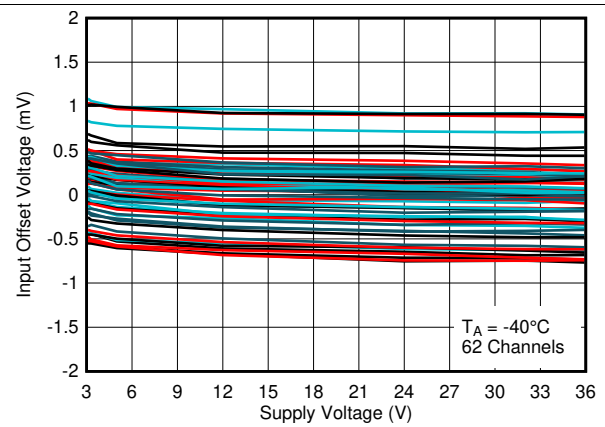

Figure 16. Input Offset Voltage vs. Supply Voltage at -40°C

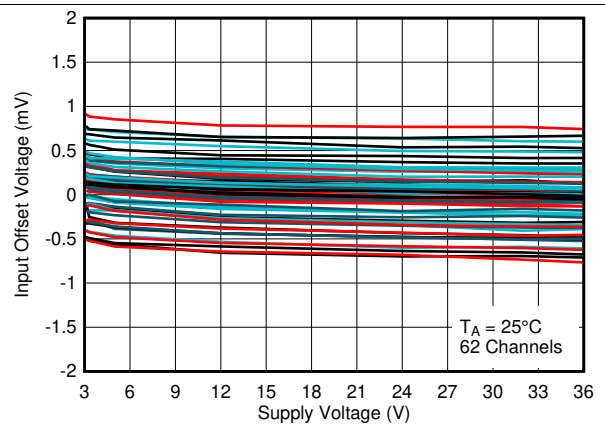

Figure 17. Input Offset Voltage vs. Supply Voltage at 25°C

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Typical Characteristics, LM393B and LM2903B (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

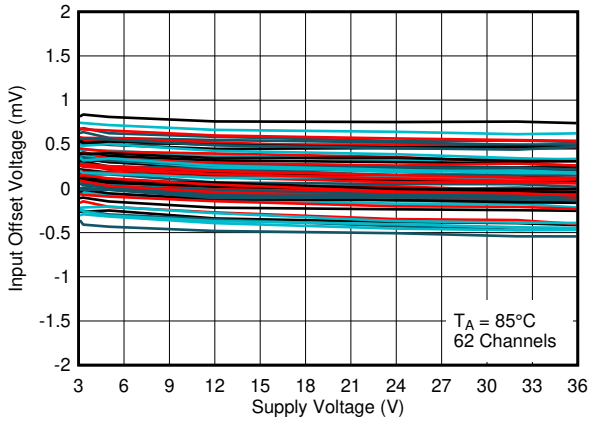

Figure 18. Input Offset Voltage vs. Supply Voltage at 85°C

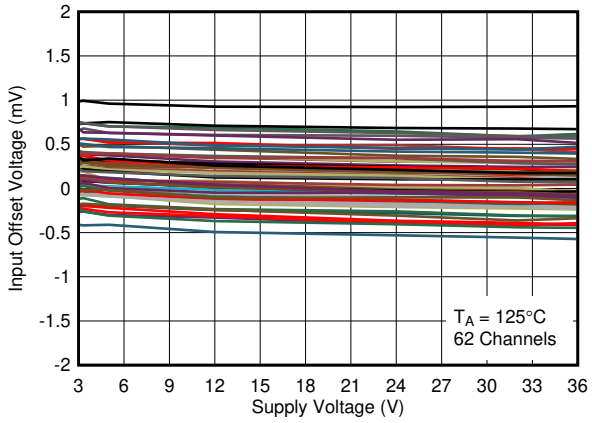

Figure 19. Input Offset Voltage vs. Supply Voltage at 125°C

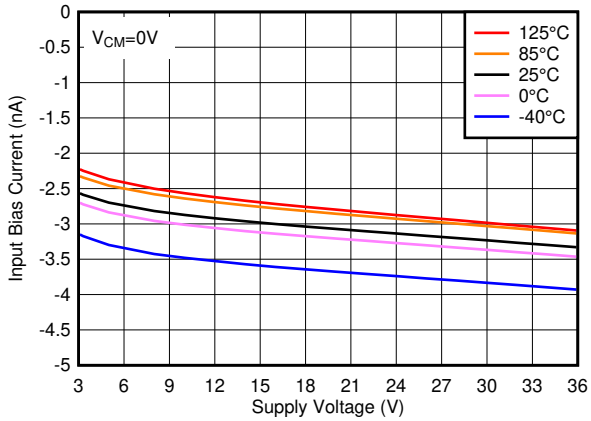

Figure 20. Input Bias Current vs. Supply Voltage

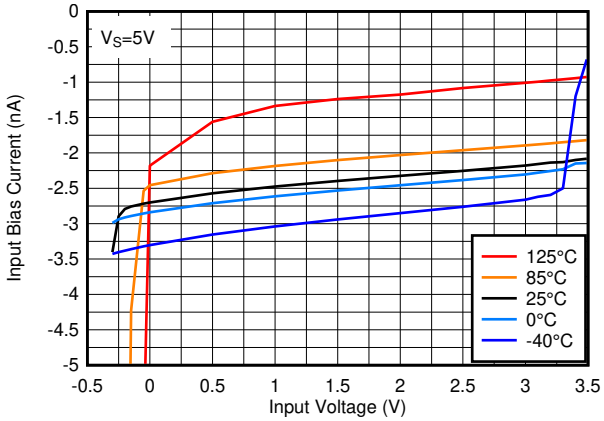

Figure 21. Input Bias Current vs. Input Voltage at 5V

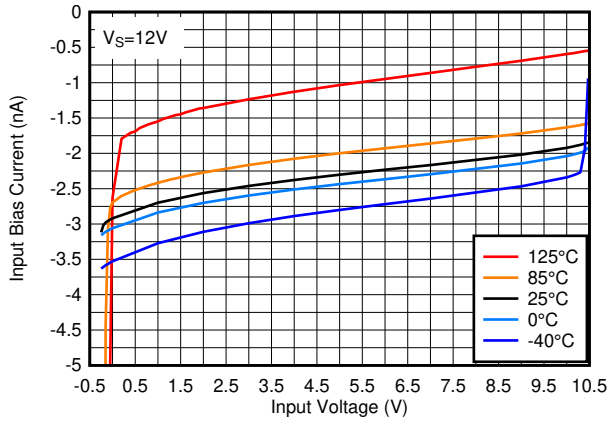

Figure 22. Input Bias Current vs. Input Voltage at 12V

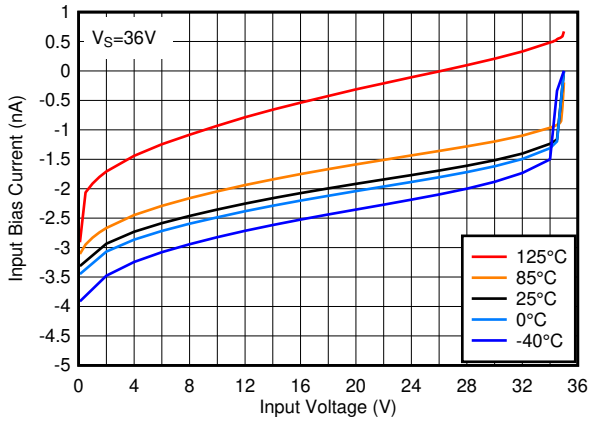

Figure 23. Input Bias Current vs. Input Voltage at 36V

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Typical Characteristics, LM393B and LM2903B (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

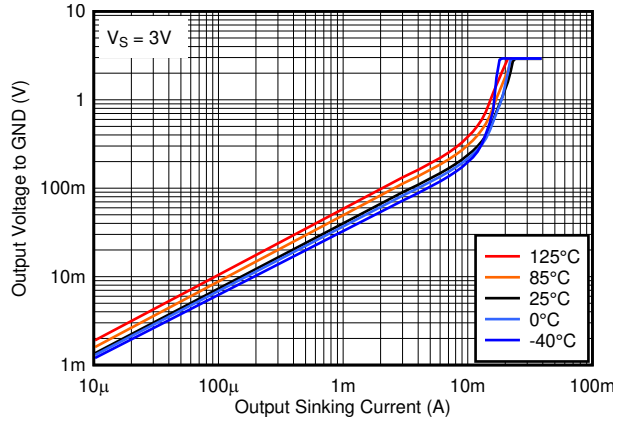

Figure 24. Output Low Voltage vs. Output Sinking Current at 3V

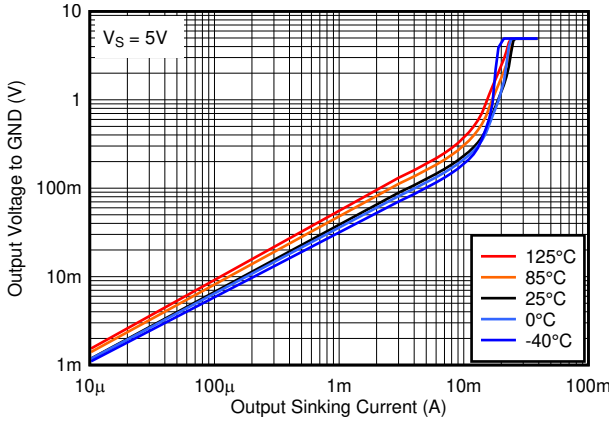

Figure 25. Output Low Voltage vs. Output Sinking Current at 5V

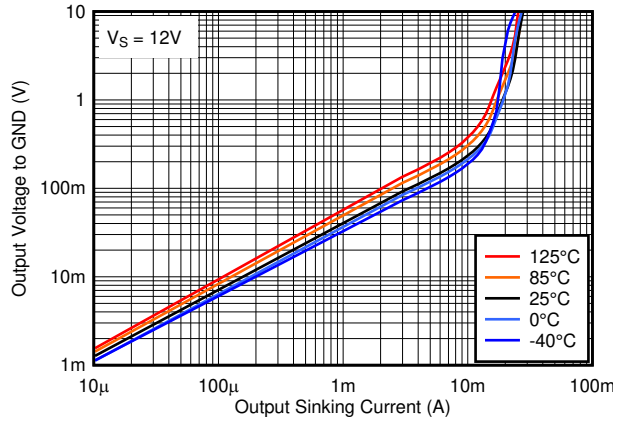

Figure 26. Output Low Voltage vs. Output Sinking Current at 12V

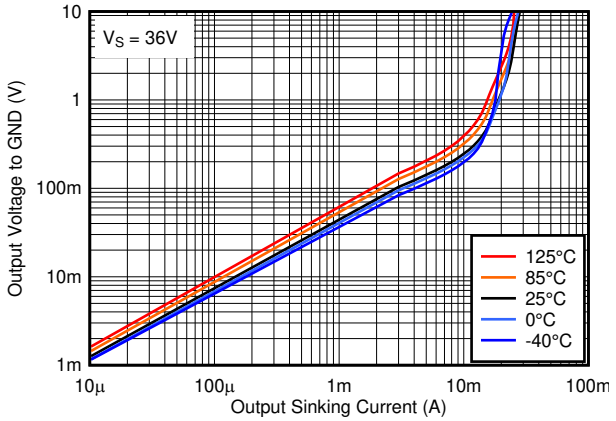

Figure 27. Output Low Voltage vs.Output Sinking Current at 36V

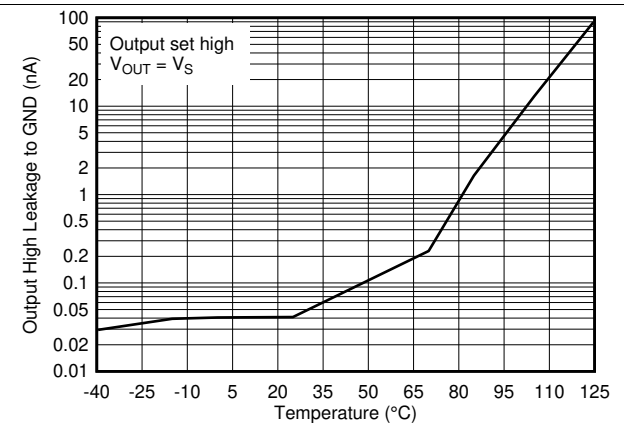

Figure 28. Output High Leakage Current vs.Temperature at 5V

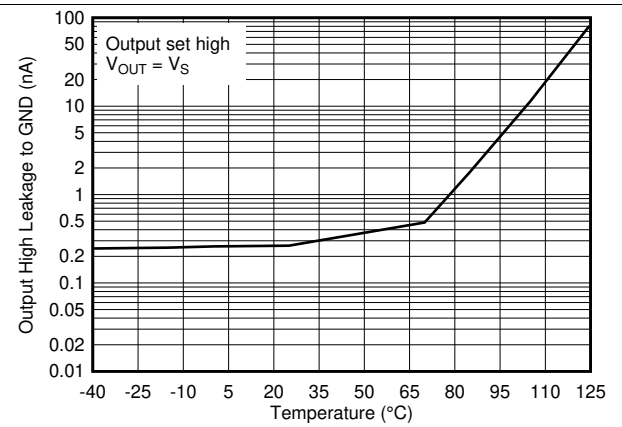

Figure 29. Output High Leakage Current vs. Temperature at 36V

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Typical Characteristics, LM393B and LM2903B (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

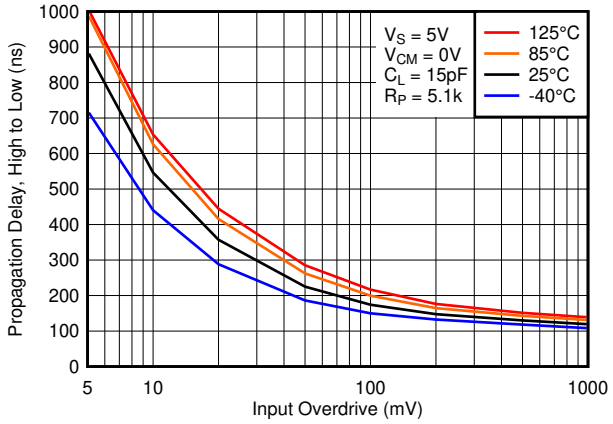

Figure 30. High to Low Propagation Delay vs. Input Overdrive Voltage, 5V

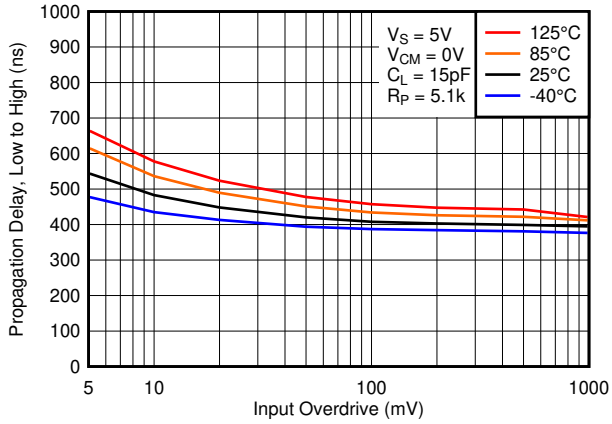

Figure 31. Low to High Propagation Delay vs. Input Overdrive Voltage, 5V

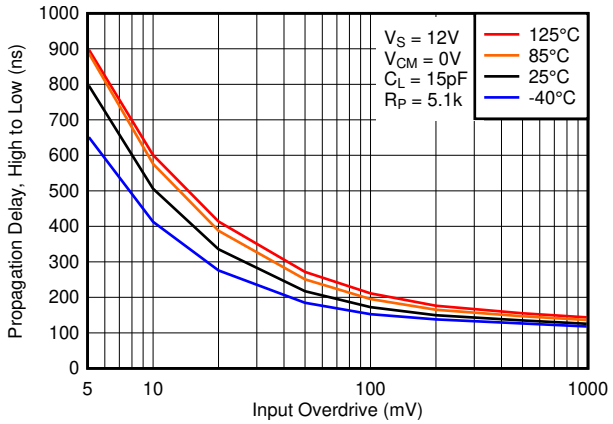

Figure 32. High to Low Propagation Delay vs. Input Overdrive Voltage, 12V

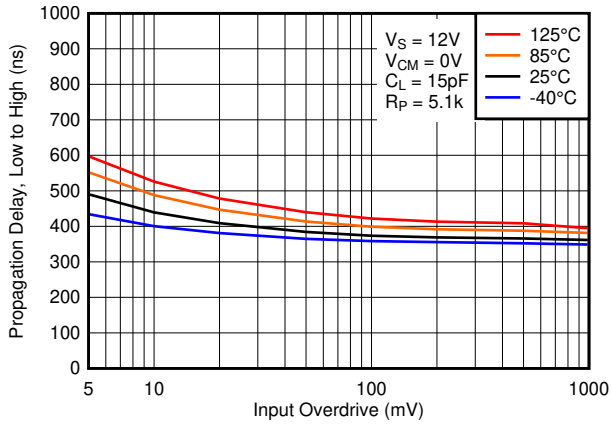

Figure 33. Low to High Propagation Delay vs. Input Overdrive Voltage, 12V

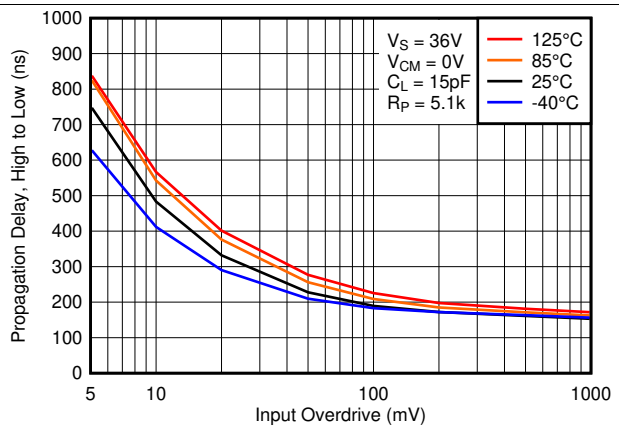

Figure 34. High to Low Propagation Delay vs. Input Overdrive Voltage, 36V

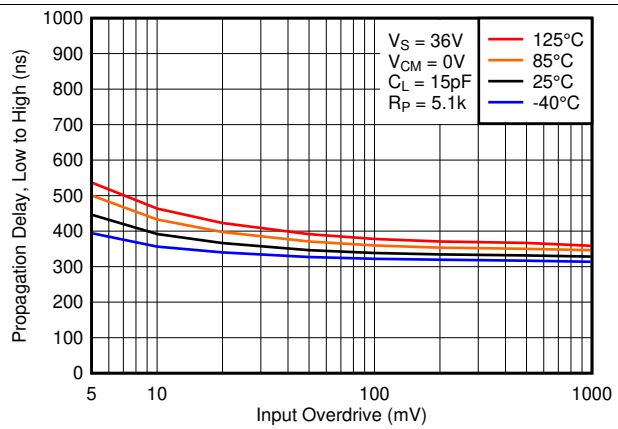

Figure 35. Low to High Propagation Delay vs. Input Overdrive Voltage, 36V

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Typical Characteristics, LM393B and LM2903B (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

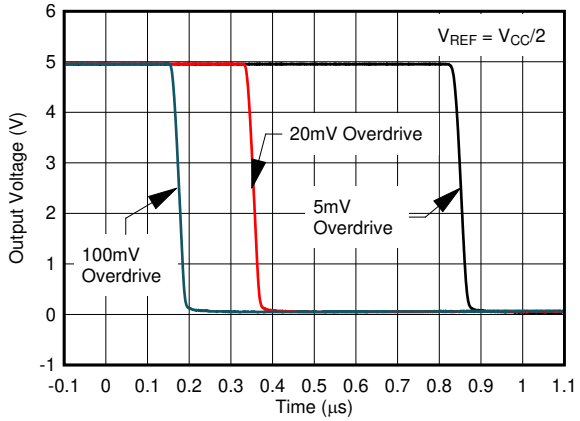


Figure 36. Response Time for Various Overdrives, High-to-Low Transition

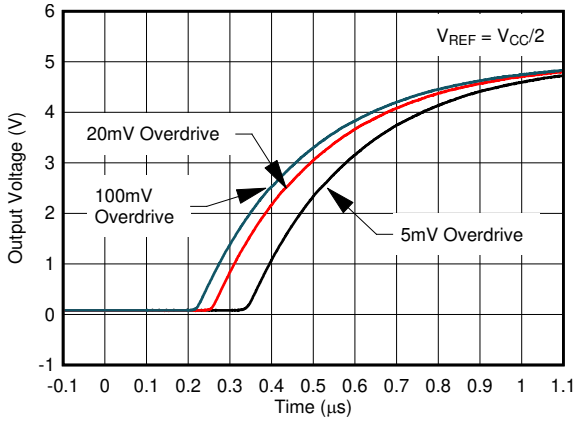


Figure 37. Response Time for Various Overdrives, Low-to-High Transition

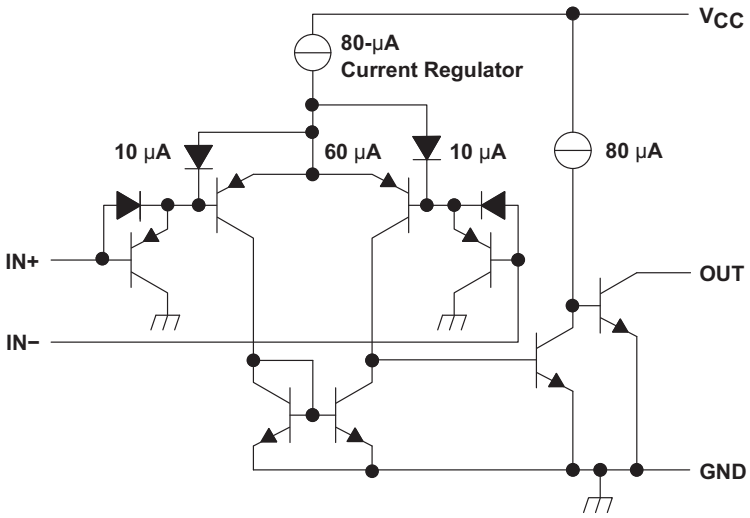
7 Detailed Description

7.1 Overview

These dual comparators have the ability to operate up to absolute maximum of 36 V (38 V for the "B" version) on the supply pin. This device has proven ubiquity and versatility across a wide range of applications. This is due to very wide supply voltages range, low Iq and fast response of the devices.

The open-drain output allows the user to configure the output's logic high voltage (V_{OH}) and can be used to enable the comparator to be used in AND functionality.

7.2 Functional Block Diagram



COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	2
Transistors	30

Figure 38. Schematic (Each Comparator)

7.3 Feature Description

The comparator consists of a PNP darlington pair input, allowing the device to operate with very high gain and fast response with minimal input bias current. The input Darlington pair creates a limit on the input common mode voltage capability, allowing the comparator to accurately function from ground to V_{CC}– 1.5 V input. Allow for V_{CC}– 2 V at cold temperature.

The output consists of an open drain NPN (pull-down or low side) transistor. The output NPN sinks current when the negative input voltage is higher than the positive input voltage and the offset voltage. The V_{OL} is resistive and scales with the output current. See Figure 3 for V_{OL} values with respect to the output current.

7.4 Device Functional Modes

7.4.1 Voltage Comparison

The device operates solely as a voltage comparator, comparing the differential voltage between the positive and negative pins and outputting a logic low or high impedance (logic high with pullup) based on the input differential polarity.

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8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The device is typically used to compare a single signal to a reference or two signals against each other. Many users take advantage of the open drain output to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes this comaprator optimal for level shifting to a higher or lower voltage.

8.2 Typical Application

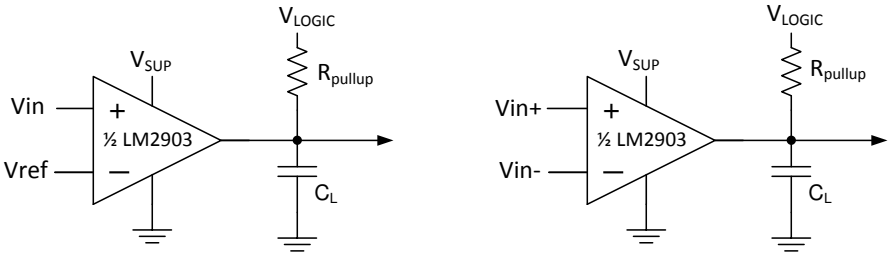

Figure 39. Single-Ended and Differential Comparator Configurations

8.2.1 Design Requirements

For this design example, use the parameters listed in Table 1 as the input parameters.

Table 1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input Voltage Range	0 V to Vsup-2 V
Supply Voltage	4.5 V to V_{CC} maximum
Logic Supply Voltage	0 V to V_{CC} maximum
Output Current (R_{PULLUP})	1 µA to 4 mA
Input Overdrive Voltage	100 mV
Reference Voltage	2.5 V
Load Capacitance (C_L)	15 pF

8.2.2 Detailed Design Procedure

When using the device in a general comparator application, determine the following:

- Input Voltage Range
- Minimum Overdrive Voltage
- Output and Drive Current
- Response Time

8.2.2.1 Input Voltage Range

When choosing the input voltage range, the input common mode voltage range (V_{ICR}) must be taken in to account. If temperature operation is below 25°C the V_{ICR} can range from 0 V to V_{CC}– 2.0 V. This limits the input voltage range to as high as V_{CC}– 2.0 V and as low as 0 V. Operation outside of this range can yield incorrect comparisons.

The following is a list of input voltage situation and their outcomes:

1. When both IN- and IN+ are both within the common-mode range:
   a. If IN- is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current
   b. If IN- is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting
2. When IN- is higher than common-mode and IN+ is within common-mode, the output is low and the output transistor is sinking current
3. When IN+ is higher than common-mode and IN- is within common-mode, the output is high impedance and the output transistor is not conducting
4. When IN- and IN+ are both higher than common-mode, the output is low and the output transistor is sinking current

8.2.2.2 Minimum Overdrive Voltage

Overdrive Voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage (V_{IO}). To make an accurate comparison the Overdrive Voltage (V_{OD}) should be higher than the input offset voltage (V_{IO}). Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive. Figure 40 and Figure 41 show positive and negative response times with respect to overdrive voltage.

8.2.2.3 Output and Drive Current

Output current is determined by the load/pull-up resistance and logic/pullup voltage. The output current produces a output low voltage (V_{OL}) from the comparator. In which V_{OL} is proportional to the output current. Use *Typical Characteristics, LMx93, LM2903 (all 'V' and 'A' suffixes)* to determine V_{OL} based on the output current.

The output current can also effect the transient response. See *Response Time* for more information.

8.2.2.4 Response Time

Response time is a function of input over drive. See *Application Curves* for typical response times. The rise and falls times can be determined by the load capacitance (C_L), load/pullup resistance (R_{PULLUP}) and equivalent collector-emitter resistance (R_{CE}).

- The rise time (τ_R) is approximately $\tau_R \sim R_{PULLUP} \times C_L$
- The fall time (τ_F) is approximately $\tau_F \sim R_{CE} \times C_L$
  – R_{CE} can be determine by taking the slope of *Typical Characteristics, LMx93, LM2903 (all 'V' and 'A' suffixes)* in its linear region at the desired temperature, or by dividing the V_{OL} by I_{out}

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8.2.3 Application Curves

The following curves were generated with 5 V on V_{CC} and V_{Logic}, R_{PULLUP} = 5.1 kΩ, and 50 pF scope probe.

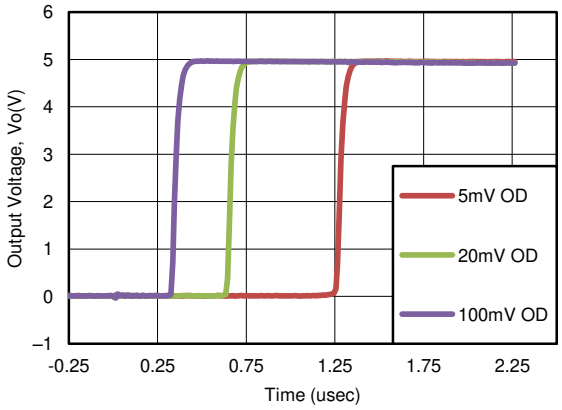

Figure 40. Response Time for Various Overdrives (Positive Transition)

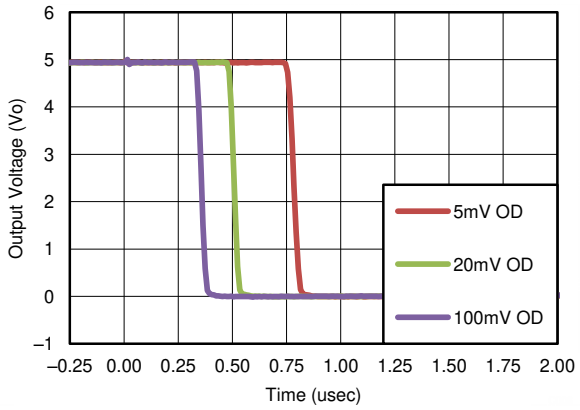

Figure 41. Response Time for Various Overdrives (Negative Transition)

9 Power Supply Recommendations

For fast response and comparison applications with noisy or AC inputs, TI recommends to use a bypass capacitor on the supply pin to reject any variation on the supply voltage. This variation can eat into the input common-mode range of the comparator and create an inaccurate comparison.

10 Layout

10.1 Layout Guidelines

For accurate comparator applications without hysteresis it is important maintain a stable power supply with minimized noise and glitches. To achieve this, it is best to add a bypass capacitor between the supply voltage and ground. This should be implemented on the positive power supply and negative supply (if available). If a negative supply is not being used, do not put a capacitor between the IC's GND pin and system ground.

Minimize coupling between outputs and inverting inputs to prevent output oscillations. Do not run output and inverting input traces in parallel unless there is a V_{CC} or GND trace between output and inverting input traces to reduce coupling. When series resistance is added to inputs, place resistor close to the device.

10.2 Layout Example

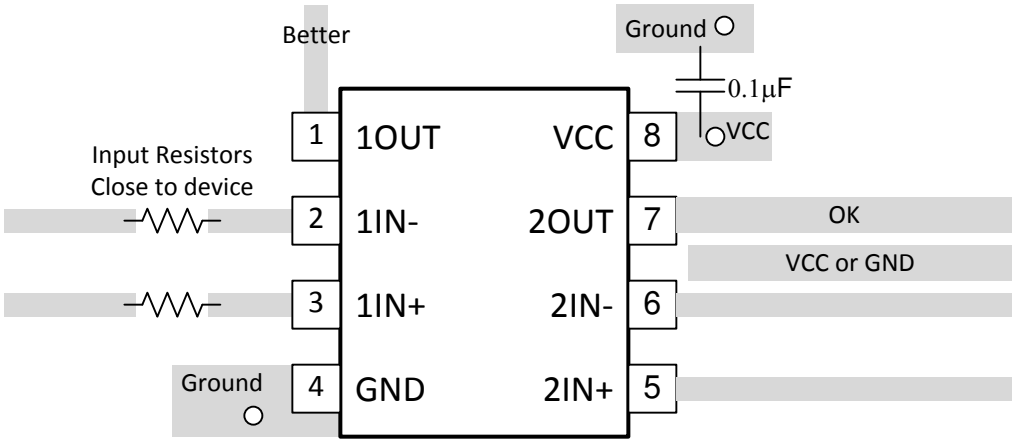

Figure 42. LM2903 Layout Example

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11 Device and Documentation Support

11.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 2. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
LM193	Click here	Click here	Click here	Click here	Click here
LM293	Click here	Click here	Click here	Click here	Click here
LM293A	Click here	Click here	Click here	Click here	Click here
LM393	Click here	Click here	Click here	Click here	Click here
LM393A	Click here	Click here	Click here	Click here	Click here
LM2903	Click here	Click here	Click here	Click here	Click here
LM2903V	Click here	Click here	Click here	Click here	Click here
LM393B	Click here	Click here	Click here	Click here	Click here
LM2903B	Click here	Click here	Click here	Click here	Click here

11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

11.3 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

11.4 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.6 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser based versions of this data sheet, refer to the left hand navigation.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM193DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	LM193	Samples
LM193DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-55 to 125	LM193	Samples
LM2903AVQDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903AV	Samples
LM2903AVQDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903AV	Samples
LM2903AVQPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903AV	Samples
LM2903AVQPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903AV	Samples
LM2903BIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903B	Samples
LM2903BIPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903B	Samples
LM2903D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2903	Samples
LM2903DE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2903	Samples
LM2903DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2903	Samples
LM2903DGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	(MAP, MAS, MAU)	Samples
LM2903DGKRG4	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	(MAP, MAS, MAU)	Samples
LM2903DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	LM2903	Samples
LM2903DRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2903	Samples
LM2903DRG3	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	SN	Level-1-260C-UNLIM	-40 to 125	LM2903	Samples
LM2903DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LM2903	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM2903P	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	NIPDAU	N / A for Pkg Type	-40 to 125	LM2903P	Samples
LM2903PSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903	Samples
LM2903PSRG4	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903	Samples
LM2903PWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	L2903	Samples
LM2903PWRG3	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	SN	Level-1-260C-UNLIM	-40 to 125	L2903	Samples
LM2903PWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903	Samples
LM2903QD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903Q	Samples
LM2903QDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903Q	Samples
LM2903QDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	2903Q	Samples
LM2903VQDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903V	Samples
LM2903VQDRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903V	Samples
LM2903VQPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903V	Samples
LM2903VQPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	L2903V	Samples
LM293AD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM293A	Samples
LM293ADE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM293A	Samples
LM293ADGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	-25 to 85	(MDP, MDS, MDU)	Samples
LM293ADGKRG4	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAUAG	Level-1-260C-UNLIM	-25 to 85	(MDP, MDS, MDU)	Samples
LM293ADR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | SN	Level-1-260C-UNLIM	-25 to 85	LM293A	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM293ADRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM293A	Samples
LM293D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM293	Samples
LM293DGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	-25 to 85	(MCP, MCS, MCU)	Samples
LM293DGKRG4	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAUAG	Level-1-260C-UNLIM	-25 to 85	(MCP, MCS, MCU)	Samples
LM293DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | SN	Level-1-260C-UNLIM	-25 to 85	LM293	Samples
LM293DRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM293	Samples
LM293DRG3	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	SN	Level-1-260C-UNLIM	-25 to 85	LM293	Samples
LM293DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-25 to 85	LM293	Samples
LM293P	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	NIPDAU | SN	N / A for Pkg Type	-25 to 85	LM293P	Samples
LM293PE4	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	NIPDAU	N / A for Pkg Type	-25 to 85	LM293P	Samples
LM393AD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393A	Samples
LM393ADE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393A	Samples
LM393ADG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393A	Samples
LM393ADGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	0 to 70	(M8P, M8S, M8U)	Samples
LM393ADGKRG4	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAUAG	Level-1-260C-UNLIM	0 to 70	(M8P, M8S, M8U)	Samples
LM393ADR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | SN	Level-1-260C-UNLIM	0 to 70	LM393A	Samples
LM393ADRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393A	Samples
LM393ADRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393A	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM393AP	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	NIPDAU | SN	N / A for Pkg Type	0 to 70	LM393AP	Samples
LM393APE4	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	NIPDAU	N / A for Pkg Type	0 to 70	LM393AP	Samples
LM393APSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	L393A	Samples
LM393APWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU | SN	Level-1-260C-UNLIM	0 to 70	L393A	Samples
LM393APWRE4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	L393A	Samples
LM393APWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	L393A	Samples
LM393BIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LM393B	Samples
LM393BIPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LM393B	Samples
LM393D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393	Samples
LM393DE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393	Samples
LM393DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393	Samples
LM393DGKR	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | NIPDAUAG	Level-1-260C-UNLIM	0 to 70	(M9P, M9S, M9U)	Samples
LM393DGKRG4	ACTIVE	VSSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	NIPDAUAG	Level-1-260C-UNLIM	0 to 70	(M9P, M9S, M9U)	Samples
LM393DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU | SN	Level-1-260C-UNLIM	0 to 70	LM393	Samples
LM393DRE4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393	Samples
LM393DRG3	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	SN	Level-1-260C-UNLIM	0 to 70	LM393	Samples
LM393DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	LM393	Samples
LM393P	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	NIPDAU | SN	N / A for Pkg Type	0 to 70	LM393P	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM393PE3	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	SN	N / A for Pkg Type	0 to 70	LM393P	Samples
LM393PE4	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	NIPDAU	N / A for Pkg Type	0 to 70	LM393P	Samples
LM393PSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	L393	Samples
LM393PSRG4	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	L393	Samples
LM393PW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	L393	Samples
LM393PWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	L393	Samples
LM393PWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU | SN	Level-1-260C-UNLIM	0 to 70	L393	Samples
LM393PWRG3	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	SN	Level-1-260C-UNLIM	0 to 70	L393	Samples
LM393PWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	L393	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF LM2903, LM2903B, LM293 :

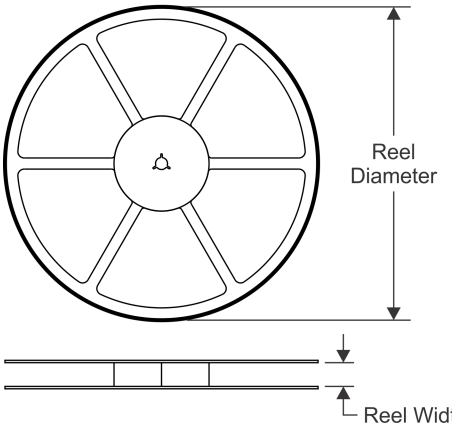
- Automotive: LM2903-Q1, LM2903B-Q1
- Enhanced Product: LM293-EP

NOTE: Qualified Version Definitions:

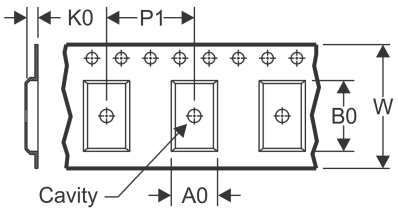
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

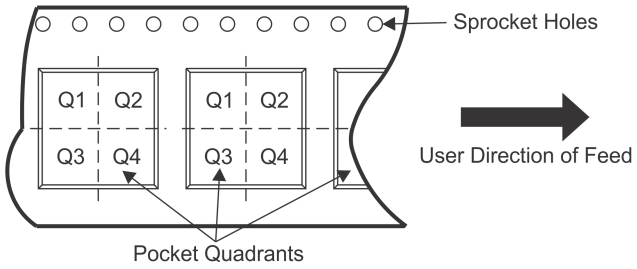


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE

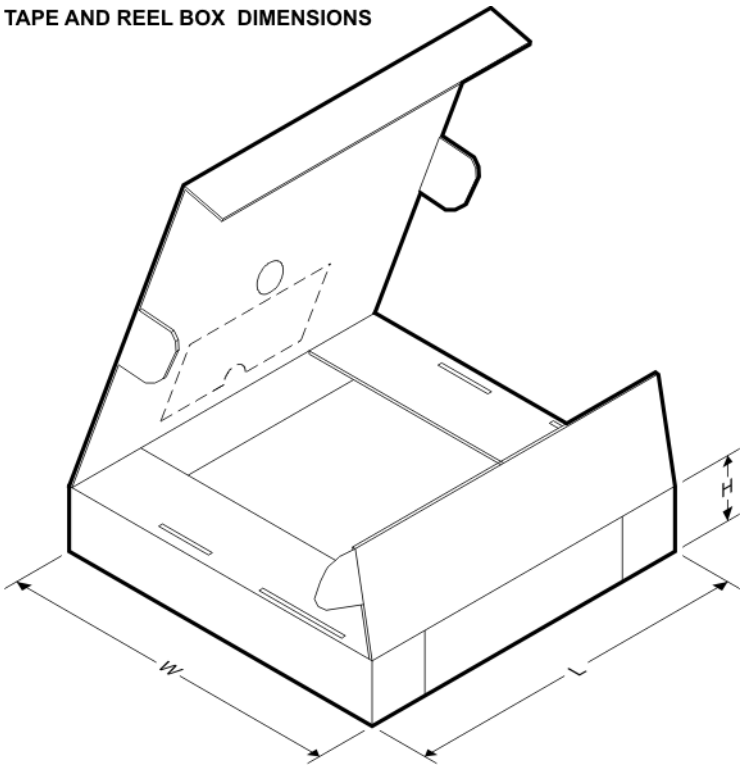


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM193DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2903AVQDR	SOIC	D	8	2500	330.0	12.5	6.4	5.2	2.1	8.0	12.0	Q1
LM2903AVQPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2903AVQPWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2903BIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2903BIPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2903DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM2903DR	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2903DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2903DR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM2903DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2903DRG3	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM2903DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2903DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2903PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2903PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2903PWRG3	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2903PWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM2903QDRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM2903VQDR	SOIC	D	8	2500	330.0	12.5	6.4	5.2	2.1	8.0	12.0	Q1
LM2903VQPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM2903VQPWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM293ADGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM293ADR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM293ADR	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293ADR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293ADR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293ADRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293ADRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM293DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293DR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM293DRG3	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM293DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM293DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393ADGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM393ADR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393ADR	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393ADR	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM393ADR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393ADRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393ADRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393APWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM393APWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM393APWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM393BIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393BIPWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM393DGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LM393DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393DR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393DRG3	SOIC	D	8	2500	330.0	12.8	6.4	5.2	2.1	8.0	12.0	Q1
LM393DRG3	SOIC	D	8	2500	330.0	15.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393DRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
LM393PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM393PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM393PWRG3	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1
LM393PWRG4	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1

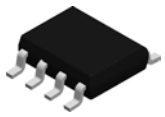
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM193DR	SOIC	D	8	2500	350.0	350.0	43.0
LM2903AVQDR	SOIC	D	8	2500	340.5	338.1	20.6
LM2903AVQPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
LM2903AVQPWRG4	TSSOP	PW	8	2000	367.0	367.0	35.0
LM2903BIDR	SOIC	D	8	2500	340.5	338.1	20.6
LM2903BIPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
LM2903DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM2903DR	SOIC	D	8	2500	333.2	345.9	28.6
LM2903DR	SOIC	D	8	2500	367.0	367.0	35.0
LM2903DR	SOIC	D	8	2500	364.0	364.0	27.0
LM2903DR	SOIC	D	8	2500	340.5	338.1	20.6
LM2903DRG3	SOIC	D	8	2500	364.0	364.0	27.0
LM2903DRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM2903DRG4	SOIC	D	8	2500	367.0	367.0	35.0
LM2903PWR	TSSOP	PW	8	2000	364.0	364.0	27.0
LM2903PWR	TSSOP	PW	8	2000	367.0	367.0	35.0
LM2903PWRG3	TSSOP	PW	8	2000	364.0	364.0	27.0
LM2903PWRG4	TSSOP	PW	8	2000	367.0	367.0	35.0
LM2903QDRG4	SOIC	D	8	2500	350.0	350.0	43.0
LM2903VQDR	SOIC	D	8	2500	340.5	338.1	20.6

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM2903VQPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
LM2903VQPWRG4	TSSOP	PW	8	2000	367.0	367.0	35.0
LM293ADGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM293ADR	SOIC	D	8	2500	364.0	364.0	27.0
LM293ADR	SOIC	D	8	2500	333.2	345.9	28.6
LM293ADR	SOIC	D	8	2500	340.5	338.1	20.6
LM293ADR	SOIC	D	8	2500	367.0	367.0	35.0
LM293ADRG4	SOIC	D	8	2500	367.0	367.0	35.0
LM293ADRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM293DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM293DR	SOIC	D	8	2500	367.0	367.0	35.0
LM293DR	SOIC	D	8	2500	364.0	364.0	27.0
LM293DRG3	SOIC	D	8	2500	364.0	364.0	27.0
LM293DRG4	SOIC	D	8	2500	367.0	367.0	35.0
LM293DRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM393ADGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM393ADR	SOIC	D	8	2500	340.5	338.1	20.6
LM393ADR	SOIC	D	8	2500	333.2	345.9	28.6
LM393ADR	SOIC	D	8	2500	364.0	364.0	27.0
LM393ADR	SOIC	D	8	2500	367.0	367.0	35.0
LM393ADRG4	SOIC	D	8	2500	367.0	367.0	35.0
LM393ADRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM393APWR	TSSOP	PW	8	2000	364.0	364.0	27.0
LM393APWR	TSSOP	PW	8	2000	367.0	367.0	35.0
LM393APWRG4	TSSOP	PW	8	2000	367.0	367.0	35.0
LM393BIDR	SOIC	D	8	2500	340.5	338.1	20.6
LM393BIPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
LM393DGKR	VSSOP	DGK	8	2500	364.0	364.0	27.0
LM393DR	SOIC	D	8	2500	367.0	367.0	35.0
LM393DR	SOIC	D	8	2500	340.5	338.1	20.6
LM393DRG3	SOIC	D	8	2500	364.0	364.0	27.0
LM393DRG3	SOIC	D	8	2500	333.2	345.9	28.6
LM393DRG4	SOIC	D	8	2500	340.5	338.1	20.6
LM393DRG4	SOIC	D	8	2500	367.0	367.0	35.0
LM393PWR	TSSOP	PW	8	2000	364.0	364.0	27.0
LM393PWR	TSSOP	PW	8	2000	367.0	367.0	35.0
LM393PWRG3	TSSOP	PW	8	2000	364.0	364.0	27.0
LM393PWRG4	TSSOP	PW	8	2000	367.0	367.0	35.0

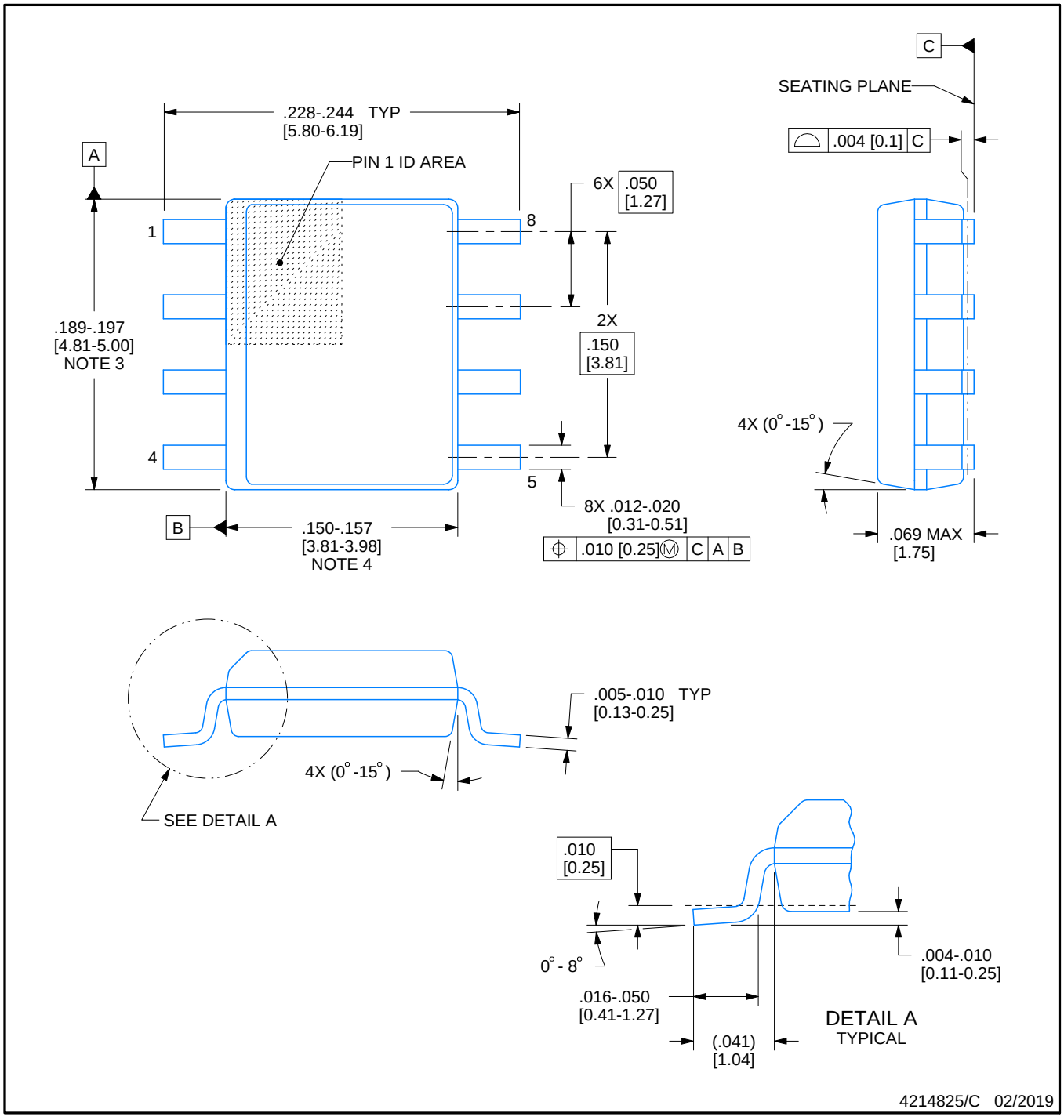


PACKAGE OUTLINE

D0008A

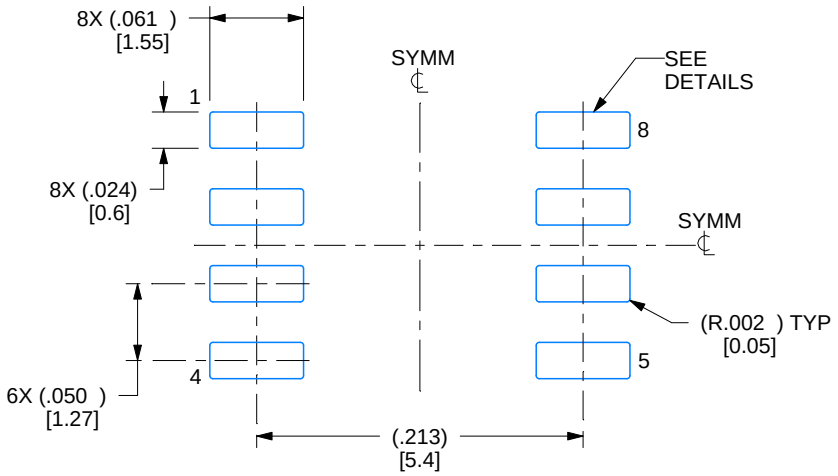
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

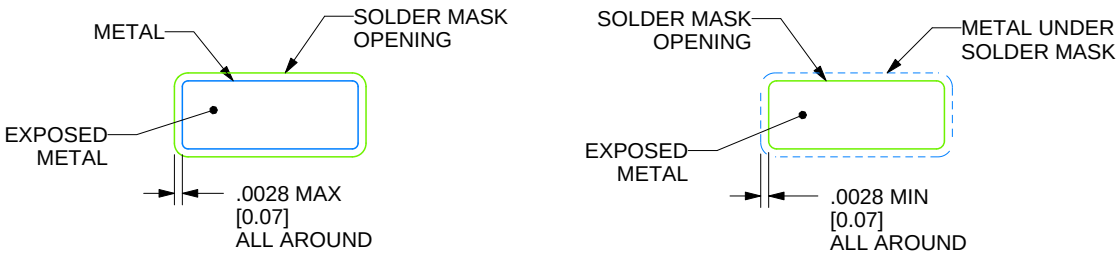


NOTES:

1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

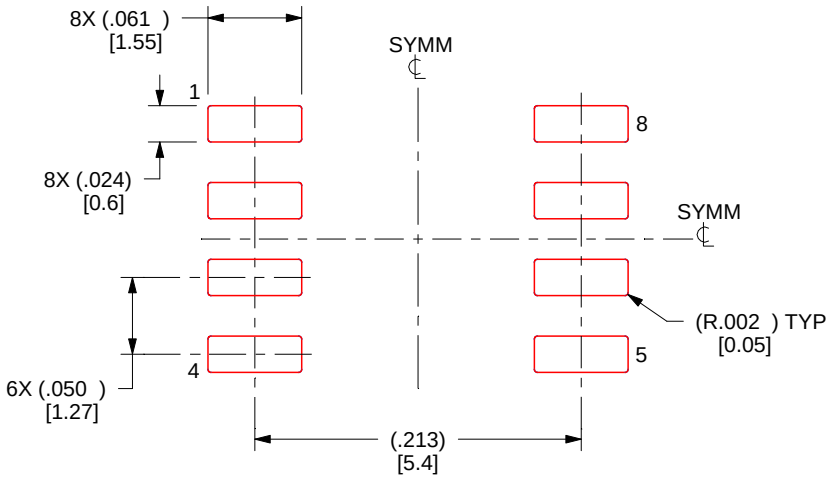
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

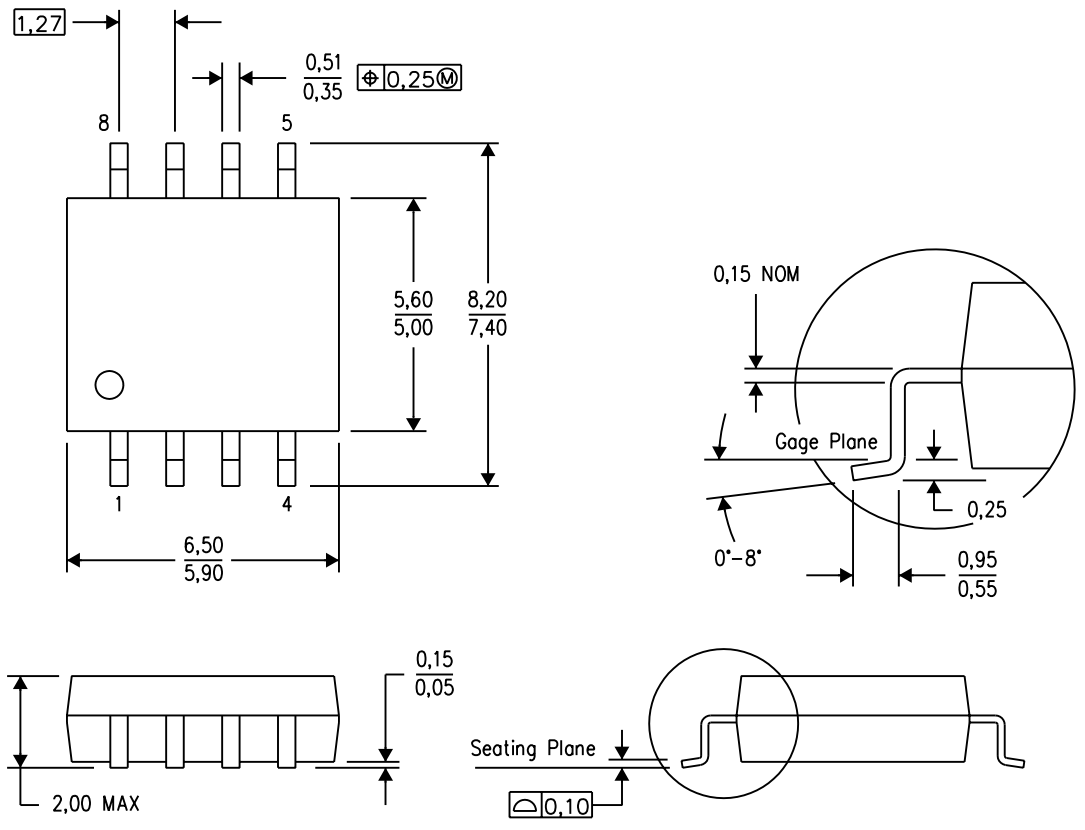
4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

MECHANICAL DATA

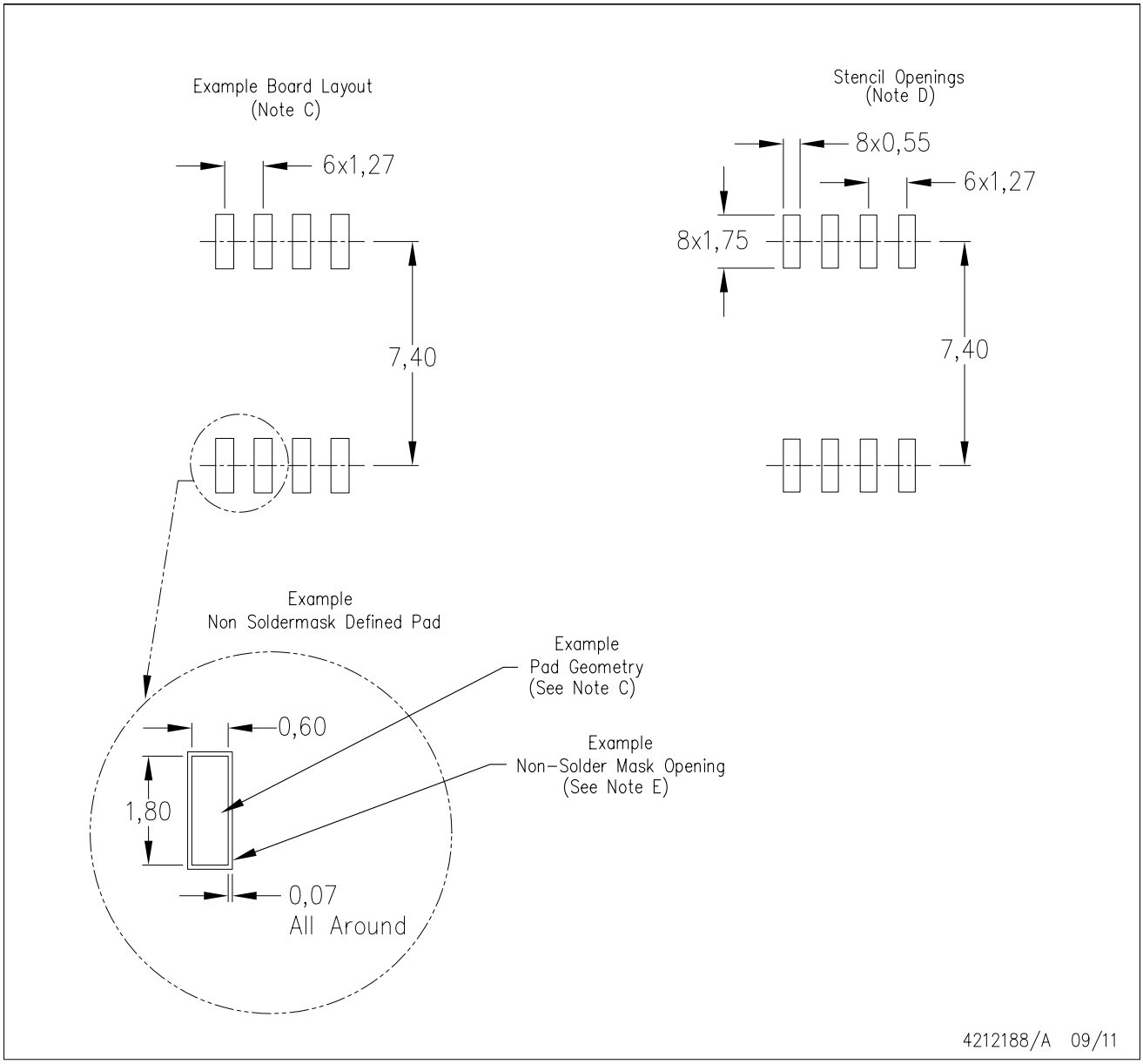
PS (R-PDSO-G8) **PLASTIC SMALL-OUTLINE PACKAGE**



4040063/C 03/03

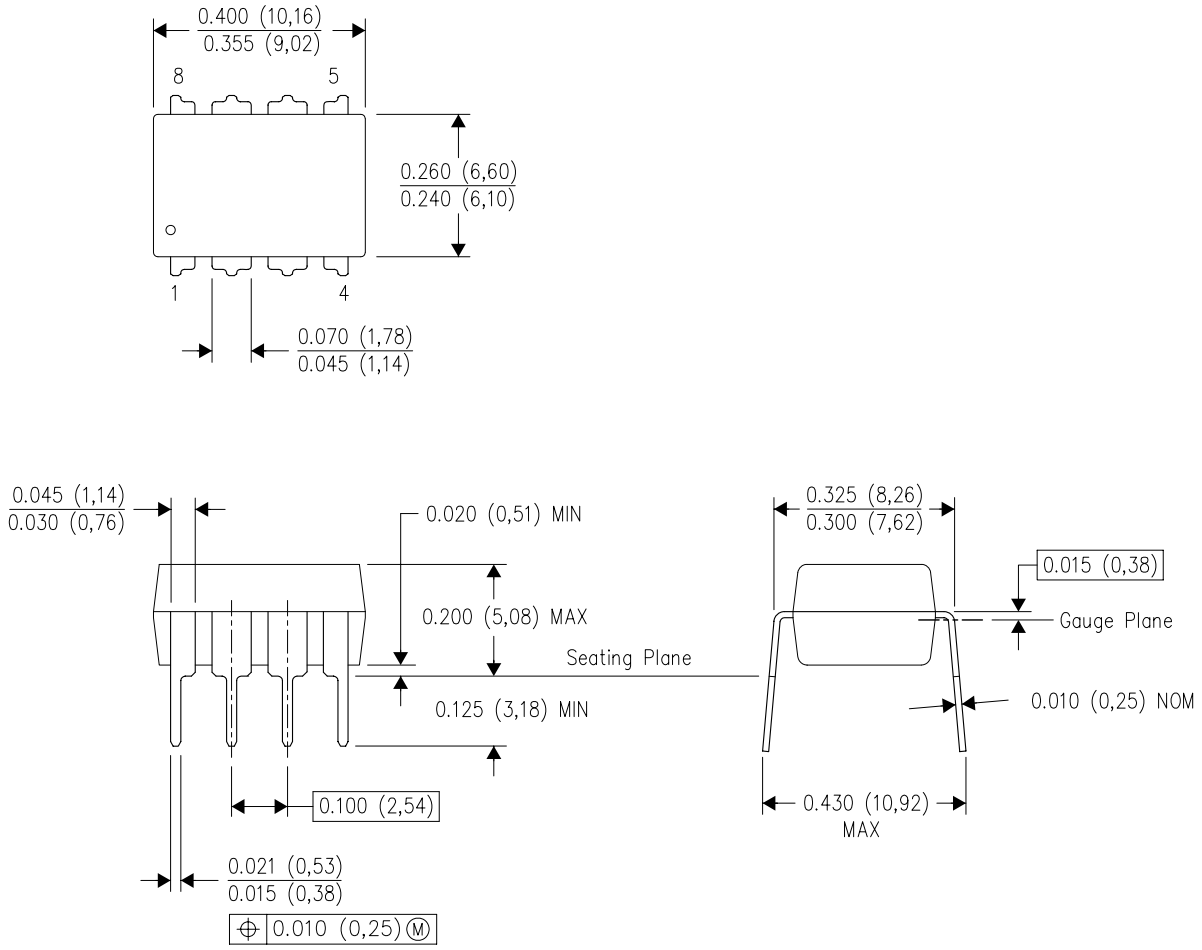
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

PS (R–PDSO–G8) PLASTIC SMALL OUTLINE



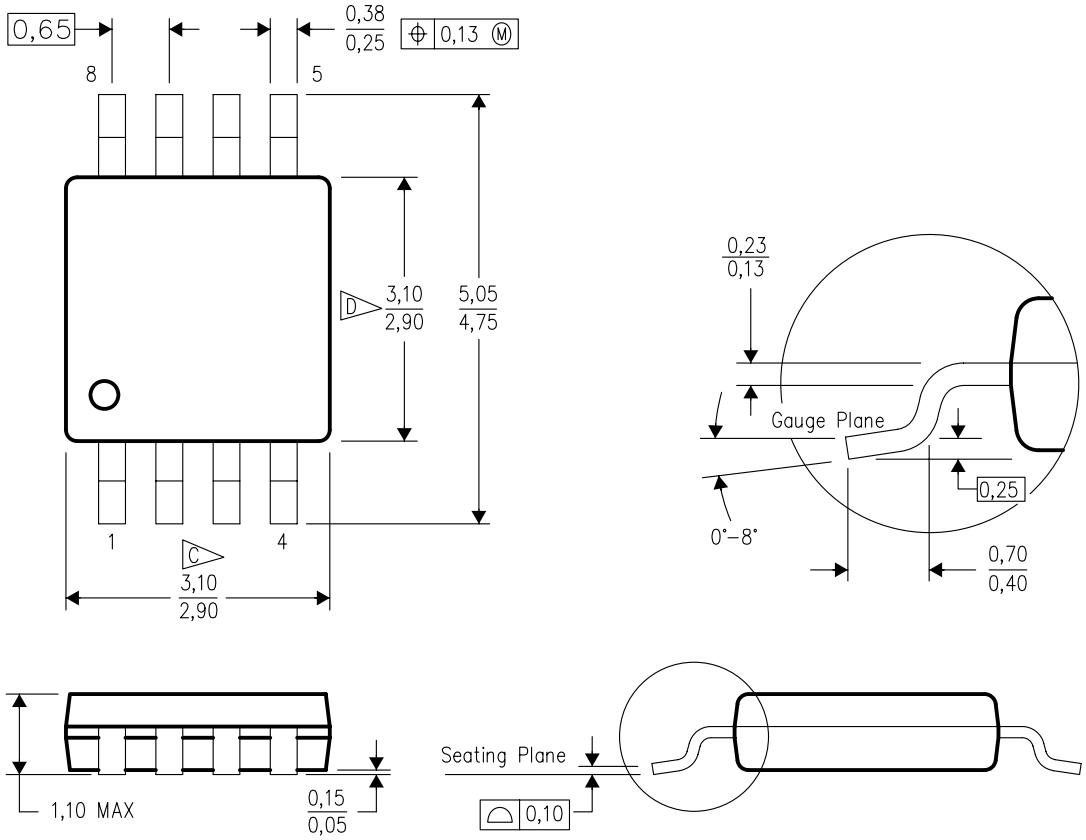
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001 variation BA.

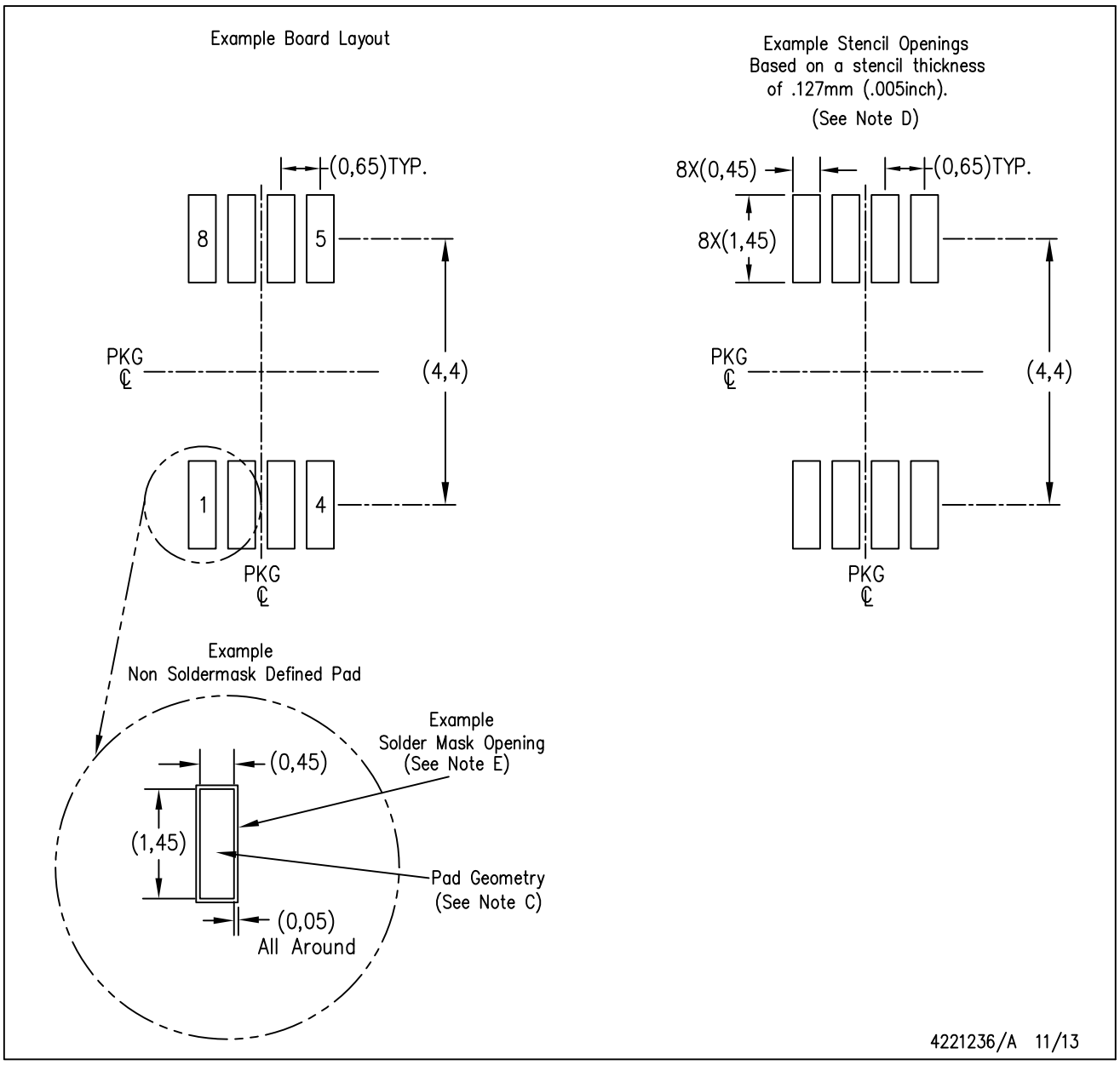
DGK (S–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



4073329/E 05/06

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
E. Falls within JEDEC MO–187 variation AA, except interlead flash.

DGK (S–PDSO–G8) PLASTIC SMALL OUTLINE PACKAGE



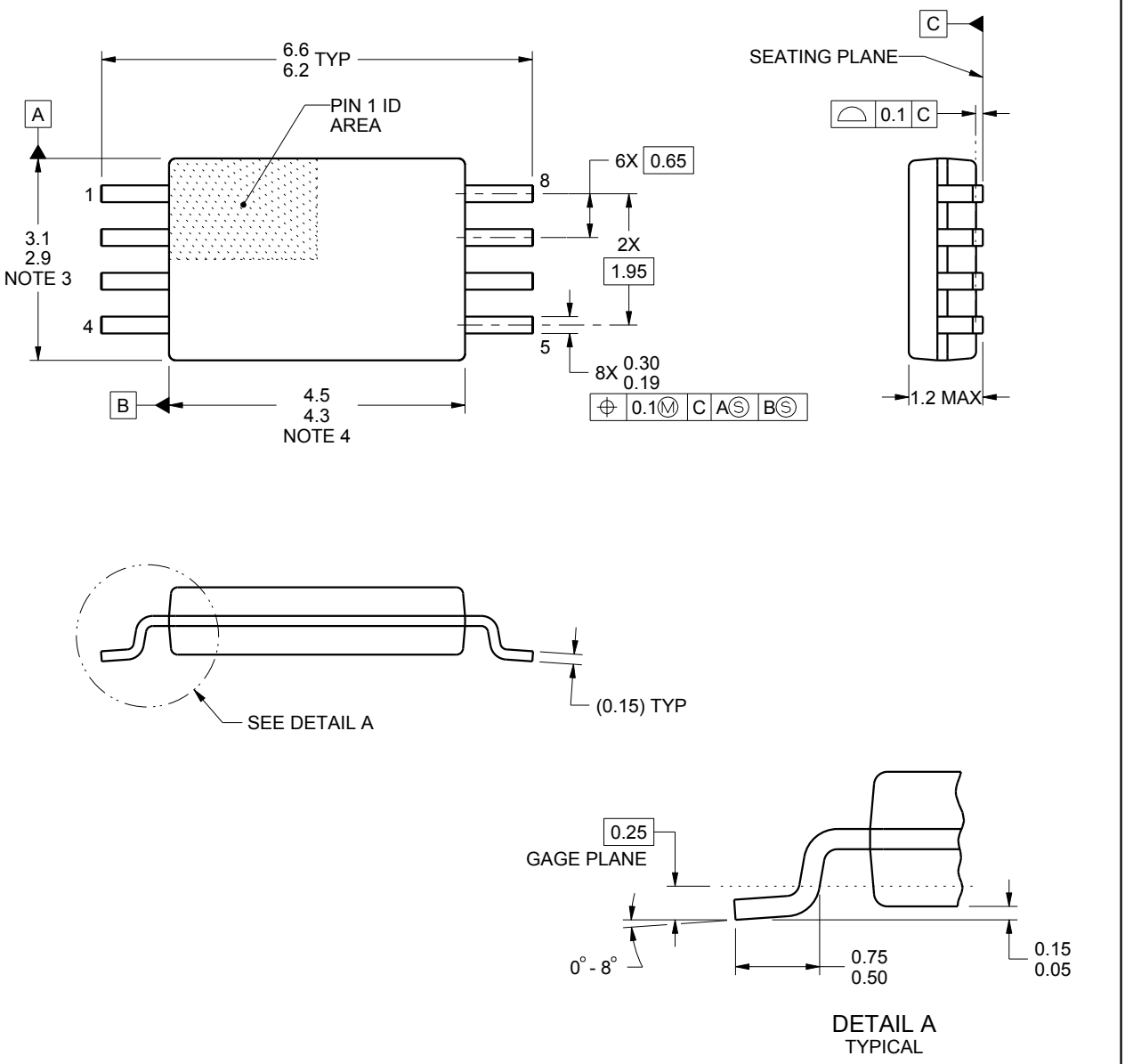
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PACKAGE OUTLINE

PW0008A

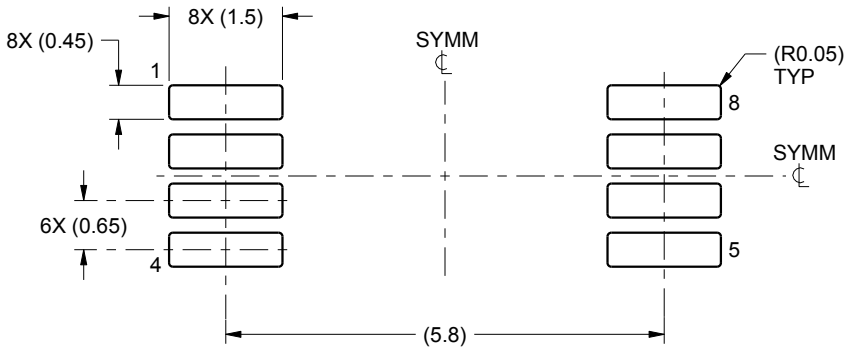
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

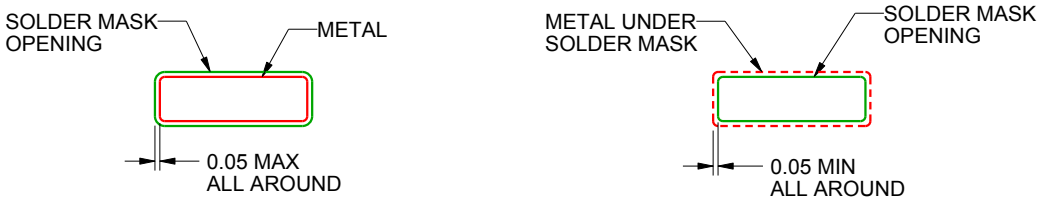


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153, variation AA.



LAND PATTERN EXAMPLE
SCALE:10X

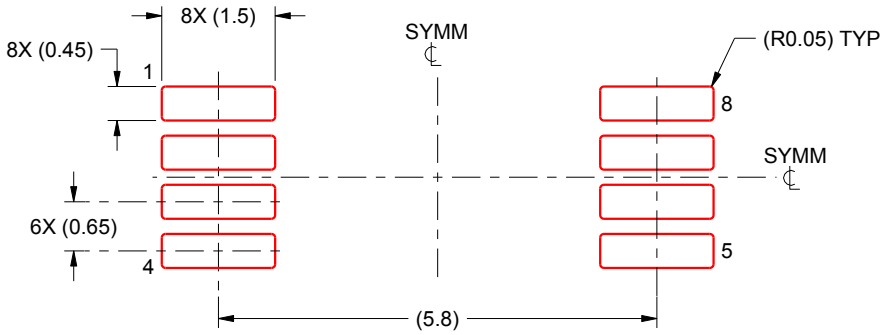


SOLDER MASK DETAILS
NOT TO SCALE

4221848/A 02/2015

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

4221848/A 02/2015

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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